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ABSTRACT

Since 1991, the National Science Foundation has conducted a series of annual competitions for awards to states under the Statewide Systemic Initiatives (SSI) program. This document reports on the progress of 21 SSI initiatives through the 1992-93 academic year. In chapter 1, "Introduction," a framework for assessing systemic reform is established and an overview of the first year evaluation activities is presented. Chapter 2, "Visions for Change: Scientific Literacy and Mathematical Power for All," discusses the visions for improved teaching and learning which are driving the systemic initiatives and the broader reform efforts in which they are embedded. Chapter 3, "Strategies for Reform," describes states' strategies for realizing their visions of change. Emphasis is placed on those parts of the system that are being targeted for reform and the theories of change underlying the states' approaches. Chapter 4, "The Governance of Statewide Systemic Initiatives: Building Collaboration, Consensus, and Coherence," describes the ways in which states have chosen to govern their systemic initiatives, raising questions about the potential strengths and weaknesses of each. The final chapter, "Looking Ahead: Challenges for Further Evaluation," concludes the report with a discussion of the issues involved in measuring the success of NSF's Statewide Systemic Initiatives program. (ZWH)

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Evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) Program: First Year Report

Volume I: Technical Report

Sponsored by the National Science Foundation

Conducted by SRI International, Menlo Park, California in collaboration with:

The Consortium for Policy Research in Education
Policy Studies Associates
Woodside Research Consortium
The Council of Chief State Schools Officers

A RED - sponsored Evaluation

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EVALUATION OF NSF'S STATEWIDE SYSTEMIC INITIATIVES (SSI) PROGRAM: FIRST-YEAR REPORT

Volume I: Technical Report

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June, 1994

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Foreword

The Statewide Systemic Initiatives (SSI) Program was established in 1990 as part of NSF's efforts to reform the delivery of K-12 mathematics and science instruction in the United States. Grants of up to $2 million per year for 5 years may be awarded to states to bring together partnerships of institutions (State Departments of Education, school districts, State Agencies for Higher Education, Institutions of Higher Education, businesses/industry, etc.) to formulate ambitious, coordinated, coherent, and comprehensive approaches to statewide reform of mathematics and science education. NSF made 10 awards in 1991, 11 in 1992, and 5 in 1993.

In 1992, the Education and Human Resources (EHR) Directorate undertook a 5-year evaluation of the SSI Program, which resides in NSF's Office of Systemic Reform. This volume is the report of descriptive findings from the first year of that evaluation. It presents a conceptual framework of systemic reform and establishes a baseline against which progress can be measured in subsequent years. Simply put, to measure the impacts of NSF's systemic education initiatives, EHR must invent "systemic evaluation." This first-year report is a vital step in the process of invention.

The SSI evaluation is sponsored by the Division of Research, Evaluation and Dissemination (RED), and is being carried out by SRI International, Menlo Park, CA. The RED Program Officer for the SSI evaluation is Susan Gross. NSF welcomes comments on its programs and products.

Daryl E. Chubin
Division Director,
Research, Evaluation and Dissemination

Executive Summary

Since 1991, the National Science Foundation (NSF) has conducted a series of annual competitions for awards to states under the Statewide Systemic Initiatives (SSI) program. In 1991, 10 awards were made, and in 1992, an additional 11 awards were made. This is a report on the progress of these 21 SSI initiatives through the 1992-93 academic year.[1] The report was prepared as part of an ongoing evaluation by a team of researchers from SRI International and its partners, the Consortium for Policy Research in Education, Policy Studies Associates, the Council of Chief State School Officers, and Woodside Research Consortium.

This first-year report is an interim document. As such, it is intended primarily to be descriptive and to establish a baseline against which progress can be measured. The description allows different systemic reform strategies to be characterized and raises key analytic questions that will need to be addressed in the future. By the third-year evaluation report, we will begin to draw conclusions about the effectiveness of the SSI initiatives.

Our evaluation is based on a conceptual framework of systemic reform, the model of change that NSF used to organize the solicitation for SSI awards. The underlying premise of the model is that attainment of world-class standards in mathematics and science education will require the replacement of isolated and piecemeal reform efforts (such as implementing a new curriculum) by ambitious, coordinated, coherent, and comprehensive approaches involving many different aspects of the education system, ranging from the preparation of teachers, to the selection of instructional materials, to the assessment of student learning, to the development of public support for improved mathematics and science education. NSF provided the states with a significant degree of latitude in deciding how to formulate and implement a systemic reform strategy.

Visions for Change: Scientific Literacy and Mathematical Power for All

The starting point for systemic reform is the creation of a set of ambitious learning goals for all students, including those often underrepresented in mathematics and science, such as minorities, females, and students living in poverty. *All of the SSIs are seeking to develop and articulate clear goals for what students should know and be able to do.* On the surface, these emerging visions appear remarkably uniform, especially in mathematics,

[1]Five additional SSIs, funded in 1993, have not been included in the evaluation to date.

where the *Curriculum and Evaluation Standards for School Mathematics* published by the National Council of Teachers of Mathematics (NCTM) is highly influential. Because there is not yet a clear set of standards in science, there is less unanimity from state to state in this content area.[2]

Despite agreement on the general goals of reform, states vary considerably on the specifics of their visions. *In particular, the states differ in how they address the issue of integration across and within content areas.* Vermont, for example, is seeking to develop an integrated mathematics and science curriculum, whereas most states are, at least in the short run, content with maintaining separate content areas. Montana provides an example of an attempt to integrate technology fully in teaching and learning mathematics (at least at the secondary level), in contrast to many other SSIs.

States also vary in how they approach the key issue of equity. Some of the SSI states have focused attention on particular underrepresented groups (for example, Connecticut, Michigan, and California concentrate funds on schools and districts serving underrepresented students); others are still grappling with the best approach to equity. States are especially challenged to reduce "tracking" in schools. *At the elementary level, this effort often involves a clash with the basic skills culture of compensatory education programs, including those funded with Chapter 1 dollars. At the secondary level, the key issues revolve around vocational versus college-bound tracks both within and across schools.* Some states have actively tackled these problems. Montana has taken the bold step of creating a single secondary mathematics curriculum for all students. Delaware has included vocational schools in its reform efforts. Most SSI states are still working out ways to provide high-quality mathematics and science for all students.

States are employing two policy instruments for communicating ambitious learning goals throughout the education system: curriculum frameworks and student assessments. Although there is disagreement as to what a curriculum framework should be (for example, only some frameworks focus on **how** mathematics or science should be taught), almost all the SSIs are using curriculum frameworks (or actual curriculum materials) to communicate a vision of ambitious learning goals.

Some SSI states, such as Kentucky, are relying heavily on student assessments as a way of providing clear messages to teachers, families, and students about what students

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[2]Neither the mathematics nor emerging science standards address implementation issues. Clearly, this is a central function of the SSIs.

should know and be able to do.[3] Creating, adapting, and implementing high-quality assessment instruments that provide useful information to a range of audiences in the state poses formidable technical and political challenges. Some SSI states have used NSF funding as a means for moving ahead with new assessments, but the amount of funding required is typically very large. For financial, political, or other reasons, many states have yet to institute plans for ambitious state assessment systems.

Strategies for Reform

States have chosen a diverse set of strategies to achieve their visions of improved mathematics and science education. Some states place greater emphasis on districts and schools devising innovative programs; others seek to spread state-developed conceptions of good practice throughout the system. Some focus on the early grades; others target the middle grades; fewer address the problems of high school. Among the most prevalent reform strategies are:

- *Model or demonstration schools,* where funds are provided, typically on a competitive basis, to a relatively small set of schools (sometimes districts) to develop effective strategies that will be disseminated to other schools (9 states).
- *Training of lead teachers or school teams* to alter the teaching and learning of mathematics in their schools (14 states).
- *Development and dissemination of new curricula* or curriculum units to replace what is currently taught in the schools (2 states).
- *Restructuring of preservice education programs* to prepare a new generation of teachers better able to put new pedagogical practices in place (10 states).
- *Mobilization of public opinion* to build public support for the goals and vision of the statewide systemic initiative (18 states).

Most states use some combination of these strategies to promote their reform efforts. *Across all states, however, there is a special focus on building the capacity of school-level educators to implement the reform agenda.* States report spending a greater proportion of their funds (28%) on professional development for currently practicing teachers and administrators than for any other activity. In addition, a large portion of the SSI funds that states pass on to local districts and schools (13% on average) supports professional development activities.

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[3]On the other hand, some states still rely on outdated assessments that send messages about student learning that do not match new goals.

In contrast, states are putting much less emphasis on reforming the preparation of teachers. Only a handful of states are spending more than 10% of their funds on preservice education (compared to a large majority doing so for inservice). Perhaps this underscores the difficulty of simultaneously reforming both K-12 education and higher education, which in many states have separate governing boards and political systems. Interestingly, within the K-12 arena, there is a greater focus by SSIs on the elementary and middle grades than on secondary schools.

A noteworthy contribution of the SSI program is that many states are focusing attention on the importance of mobilizing public support for reform of mathematics and science education. Public awareness and support are often underestimated by reformers, who may believe that "everyone" accepts improving mathematics and science education as high-priority goals. There is some evidence that the public does not see the same need. Four SSI states report using more than 10% of their NSF funds for public-awareness activities, and all but three report using some (but less than 10%) of their SSI funds for this purpose.

Overall, the SSI states were successful in obtaining more than a 100% "match" of other funds to use in support of their systemic initiatives. Of these other funds, the largest amount (about 36%) came from the state and local portion of the Eisenhower Mathematics and Science Education Program. Almost as much (34%) came from state sources.

Finally, most SSIs are integrated into a larger series of state reforms that have been under way for years. In California, for example, SSI funds are used to support ongoing reform efforts geared to the development of curriculum frameworks, adoption of instructional materials that meet state standards, and piloting of a number of performance-based assessments. In a few cases, however, the SSI is at odds with other state reform efforts. Some states have had relatively few reforms under way before the SSI. In those states the systemic initiative has set the agenda for major reform, with the potential of introducing a framework for the development and delivery of improved mathematics and science education. The reformers in these states face the disadvantage of having relatively little to build on.

Governance and Collaboration

The ways that institutions and agencies interact and collaborate in the interests of promoting systemic reform are likely to have an effect on how well they succeed. To

date, the SSI states are governing their efforts at systemic reform in very different ways. It is too early to predict how these governance patterns will affect the SSI initiatives.

The norm among the SSI states is to involve several different institutions and agencies from the outset. Within this common pattern, two overlapping but distinct approaches are to organize the efforts through internal (state agency) leadership or through external leadership.

External leadership for systemic reform is a potentially interesting innovation. In several states, whole new entities have been created to govern the SSI, such as the Connecticut Academy for Education in Science, Mathematics, and Technology or the Maine Mathematics and Science Alliance. Advantages of such an approach include avoidance of red tape, the ability to hire or attract better-qualified staff, stronger ties to the mathematics and science communities, and the ability to survive changes in state leadership.

Internal leadership is somewhat more common for the SSIs than external leadership. Advantages are said to include closer ties with other state programs and reform initiatives, greater knowledge of federal programs, and an understanding of state policy-making mechanisms.

Whether one form of leadership, internal or external, is better for particular states remains to be seen. The lessons learned about governance will yield alternative models that states can share and that NSF can disseminate.

Looking Ahead: Challenges for Further Evaluation

The initiatives supported by the SSI program are complex, and many are only in the early stages of implementation. As we proceed with the evaluation of the program, we need to address a number of challenges.

First, SSI is not implemented in a vacuum. A wide array of other reform initiatives is at work in many states, ranging from school finance reform to changing the federal Chapter 1 program so that it encompasses more than just "basic skills." To understand the development of the state initiatives and to judge their contribution to reform, we must evaluate them within this broader context of reform.

Second, the evaluation to date has focused principally on the infrastructure that SSIs are building to improve their systems of mathematics and education. Yet, the ultimate goal of the SSI program and the individual state initiatives is to affect the

teaching and learning of mathematics and science. In the future, we will focus more on districts, schools, teachers, and students. Understanding the interactions of different levels of the education system is an important goal.

Third, certain common reform strategies, such as the development of curriculum frameworks and new assessment systems, require considerable in-depth analysis. These areas will continue to be significant parts of the evaluation each year.

If we meet these challenges, the evaluation will continue to reap lessons from the states that will benefit NSF's work with other programs and initiatives (e.g., the Urban Systemic Initiatives, Collaboratives for Excellence in Teacher Preparation, and the Rural Systemic Initiatives). Finally, this knowledge can be disseminated to diverse audiences outside NSF.

1 INTRODUCTION

In 1990, the National Science Foundation launched the Statewide Systemic Initiatives (SSI) program soliciting proposals from states to create broad-based statewide coalitions to undertake ambitious, comprehensive, and coordinated reforms of science, mathematics, and technology education. This solicitation marked a new approach to NSF's support for the improvement of mathematics and science education. The typical SSI award is for as much as $10 million over 5 years. This program is significant in that it calls for statewide, comprehensive initiatives supported by the governor and involving all key players in mathematics and science education.

With SSI, NSF has redefined its role in supporting change, reflecting a new vision of what it will take to improve student performance in mathematics and science and meet world-class standards. In this new role, NSF sees itself as a "strategic broker," which "brings together those who have identified problems with those who have the resources and skills to help solve those problems... [and] provides not only money in terms of resources, but serves as a catalyst for new ideas and processes" (Massey, 1993). The strategy is to prompt states to bring together all key players (teachers, parents, university researchers, business leaders, etc.), to articulate a vision of effective mathematics and science education in the state, and then identify the elements of their systems of education that need to be changed to realize this vision (Massey, 1993).

This strategy reflects a growing consensus among education reformers that significant improvement in the nation's schools will require more comprehensive and coherent approaches, driven by clear and ambitious learning goals (Fuhrman, 1993; Smith & O'Day, 1991). The SSI model of change supports systemwide, coherent reform of curriculum frameworks, instruction, teacher education, and student assessment. These reform efforts are to be designed and implemented with the cooperation of all key players in the mathematics and science communities. This model moves beyond isolated activities that are typically designed to target only one component of the educational system.

The Statewide Systemic Initiatives program represents both a change from previous NSF approaches to supporting reform and an exceedingly ambitious agenda for improving the state of mathematics and science education in the nation. NSF hopes that the statewide systemic initiatives will alter statewide systems of education, leading to

significant improvements in classroom practice consistent with both state goals and accepted professional standards (e.g., National Council of Teachers of Mathematics, 1989) and in student learning.

NSF has contracted with SRI International and its partners, the Council of Chief State School Officers, the Consortium for Policy Research in Education, and Policy Studies Associates, to conduct an evaluation of the program. This document is the first-year evaluation report. Our intention here is not to provide a preliminary report card, either on the SSI program as a whole or on individual systemic initiatives. Rather, we use this report as an opportunity to describe patterns across states' approaches to systemic reform and then to raise key questions that will be addressed in the evaluation.

In this introductory chapter, we first outline the framework we are using to map statewide systemic reform initiatives. We then describe how this framework can be used to examine very divergent state approaches to reform. Next, we briefly review our data collection activities during the first year of the evaluation, which form the basis for the subsequent chapters of the report. Finally, we provide an overview of the rest of the document.

A Framework for Assessing Systemic Reform

The Statewide Systemic Initiatives program is based on a general model of change, commonly referred to as "systemic reform," which can be used as a framework for examining the progress of the statewide systemic initiatives and the broader state reform efforts in which the projects are located. By "framework," we are referring to a conceptual map that identifies key factors and asserts likely relationships among them (Miles & Huberman, 1984).[1] As such, a framework helps to guide data collection and analysis. Experience in the field and initial data analysis in turn can help to refine the conceptual framework. A well-specified and sufficiently refined framework can ultimately be useful not only for guiding research but also for specifying key improvement points in the system for policy-makers and practitioners. We present such a framework in Figure 1, which we describe in greater detail below.

The logic behind systemic reform is that changes in the teaching and learning of mathematics and science are needed to improve student performance to meet world-class

[1] Such a framework is analogous to but different from a statistical model, which specifies variables and hypothesizes the strength of directional relationships among them that can be empirically tested.

standards. These changes must begin with a clear and ambitious vision of what students should learn and be able to do (Fuhrman, 1993; Smith & O'Day, 1991). Central to this vision is the belief that such high standards must be applied to all students, not just those who are preparing for advanced careers in mathematics and science. In particular, this vision represents a dramatic expansion of both access and attainment in learning mathematics and science for traditionally underrepresented groups (O'Day & Smith, 1993).

Creating such a vision, especially one that can affect practice, however, requires the unprecedented collaboration of key players in the mathematics, science, education, policy-making and business communities. Conflicts between key interest groups and central communities, such as teachers, local administrators, and state policy-makers, can make it impossible to build the consensus, capacity, and commitment necessary to create systemic reform (Elmore & McLaughlin, 1988). The composition of the leadership group that emerges, the nature of their participation, their commitment to the vision that is developed, and their willingness to sustain the effort may be important factors in the success of the systemic initiatives.

This vision of ambitious learning goals, supported by the leadership and collaboration of the key institutional and individual players, needs to set forth coordinated and coherent policies and practices at both the state and local levels. These efforts are meant to send a clear and reinforcing message through the system in support of the ambitious learning goals, build support for the vision, and provide the assistance, flexibility, and pressure necessary for practitioners to succeed. For the sake of discussion, we place these policies and practices into four general categories: policy instruments, capacity building, authority relations, and mobilization of opinion.

Policy instruments refers to a range of practices, inducements, and mandates that seek to alter what takes place in classrooms (McDonnell & Elmore, 1987). Examples of such instruments include policies that change requirements for teacher certification, rules about the adoption of materials and tools for the classroom, and curricular guidelines. For example, the creation of a high-stakes accountability system (as in Kentucky, where rewards or sanctions are to be meted out to schools depending upon students' performance over time) can be an effective policy instrument to get teachers to focus on reform goals.

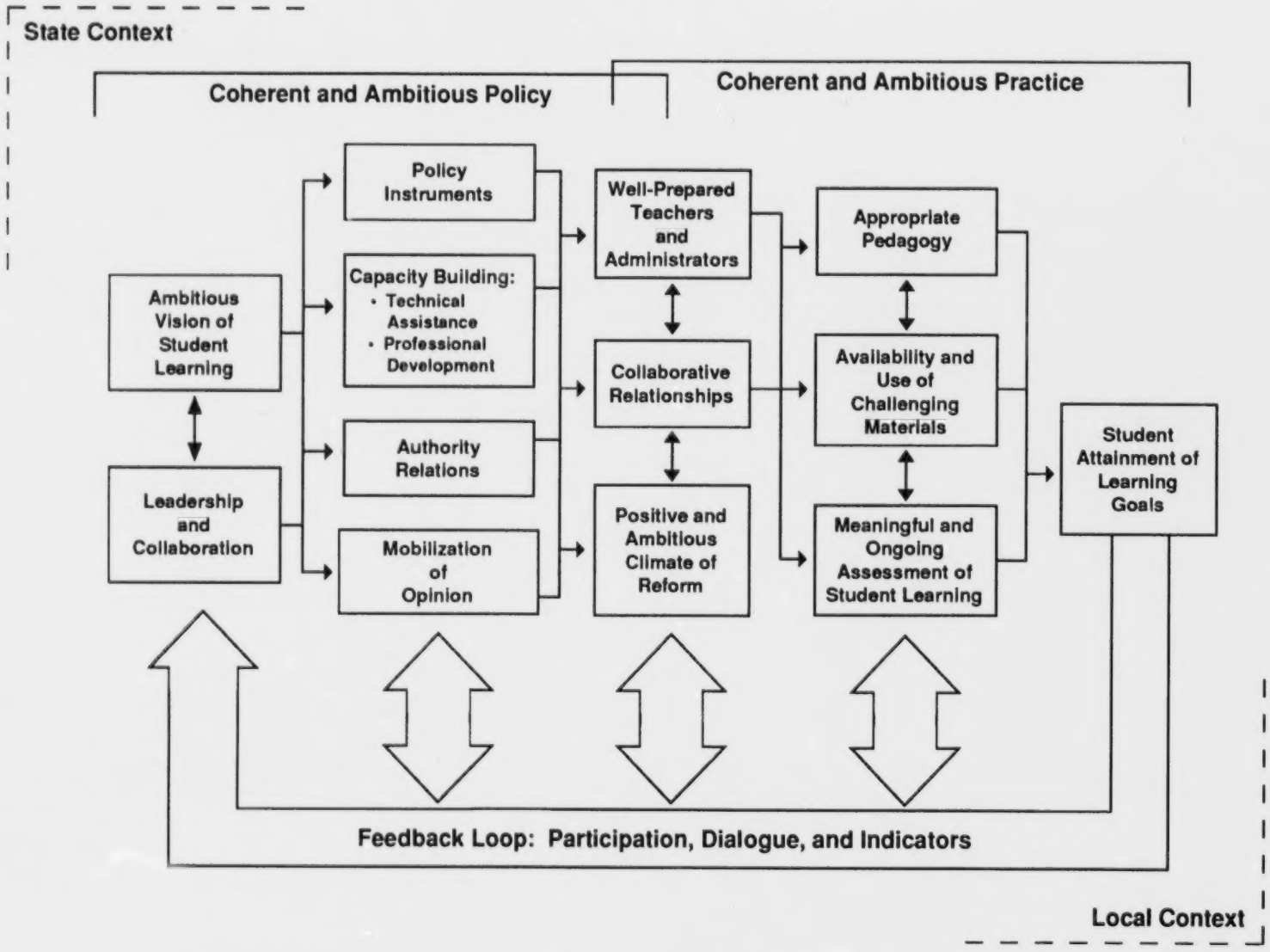

FIGURE 1 A FRAMEWORK FOR EVALUATING SYSTEMIC REFORM

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Capacity building refers to a host of activities designed to prepare individuals and institutions at all levels of the system to acquire the skills and knowledge necessary to accomplish the ambitious tasks that systemic reform demands of them (David, 1993). Educators at all levels of the system face capacity problems. The biggest capacity issue facing the systemic reformers, of course, is the competence of school practitioners to teach the more challenging standards. Teachers are being asked to have greater understanding of their subjects, to adopt new methods, to be more accountable, to change their views of students, to cope with more heterogeneous classrooms, and to take a more active role in governance (Fuhrman, 1993). Yet, whether at the state, district or school level, staff typically need greater capacity to prepare teachers to use the new frameworks, methods, and assessments. They need capacity to provide on-site assistance to support teachers' efforts to use new techniques (David & Goren, 1993).

There is also an issue of fiscal resources, especially during difficult economic conditions, and especially given the inequities that characterize school spending within and across states. Change in mathematics and science education will demand resources for staff time, materials, training and assistance, and technology.

Authority relations refers to the distribution of power through the intergovernmental system (e.g., state education agencies [SEAs], local school districts, and building-level staff). Systemic reform calls for clarifying and raising standards and direction from the "top" (e.g., the state) combined with greater authority and accountability at the "bottom" (e.g., the school level). This aspect of systemic reform, often referred to as "the authority for accountability swap," reflects the recognition of the inability of centralized, top-down regulation to build practitioner commitment and release the energies of school staffs. Proponents of systemic reform insist that individual schools retain broad discretion over instruction. From this perspective, the state should provide direction and support through curriculum standards, instructional materials, assessments, and staff development, but should refrain from prescribing the details of classroom practice (Newman & Clune, 1992).

Mobilization of opinion refers to efforts to get professionals, e.g., teachers, higher education faculty, administrators, and policy-makers, to adopt a common vision of reform and to get support for that vision from the public, especially parents and business leaders (Elmore & McLaughlin, 1988). Items often overlooked in discussions of systemic reform include persuading: state and local policy-makers to develop more coherent policy and focus their attention on a common vision; state legislators to appropriate sufficient funds

and change necessary legislation; thousands of teachers and administrators to alter their practice; and students and parents to accept—even demand—changes that are a central part of any comprehensive and ambitious reform.

Taken together, a coherent approach to policy development, sufficient capacity building, flexible authority relations, and energetic mobilization of support are meant to create the conditions necessary at the local level to make reform possible. These conditions include well-prepared teachers and administrators capable of making ambitious goals a reality in their schools; collaborative relationships between professionals within schools, and between schools and districts, that allow for creative approaches to teaching and learning; and an overall climate, both within and outside the school walls, that supports ambitious reform efforts. It is only within this overall context, according to the logic of systemic reform, that we can expect sustained and widespread changes in practice at the classroom level. The changes vary to some extent from state to state, but the overall goals for classroom practice are usually quite similar across the states, and are consistent with the national education goals in mathematics and science. Systemic reform is intended to promote change at the classroom level based on:

- *Appropriate curricula* that provide challenging content for all students, emphasizing the importance of thinking as well as facts and procedures. Curricula should be organized around major principles that have been identified as important by experts in these fields, such as the National Council of Teachers of Mathematics and the American Association for the Advancement of Science. Many curricular units are expected to have clear ties to real-world applications of science, mathematics, and technology that increase students' appreciation for the usefulness of their schoolwork.

- *Appropriate pedagogy* that promotes the development of critical thinking and problem-solving abilities through the active engagement of students and teachers in investigations that lead to shared understandings of fundamental concepts and principals. Learning tasks are expected to incorporate instructional technologies as both tools and vehicles for understanding. Increasingly, classroom tasks are expected to involve students in group work as well as independent work.

- *Assessment of student learning* that is well integrated and aligned with instruction and that provides information useful to students and teachers, as well as to others, such as district and state policy-makers. Assessment systems that focus too narrowly on partial goals, such as learning facts, or that otherwise distort the original vision of ambitious learning goals, are to be modified or replaced.

The ultimate goal, of course, is the realization of the ambitious learning goals that prompted the reform effort in the first place. These goals include not only raising students' achievement, but increasing participation in advanced mathematics and science courses, improving attitudes about mathematics and science as career goals, and increasing access to high-quality mathematics and science among underrepresented student groups in these fields.

Top-Down Versus Bottom-Up: A False Dichotomy

The model of systemic reform guiding our framework should not ignore lessons from years of implementation research suggesting that practitioners' beliefs and authority are every bit as vital as those of people at the state level (Clune, 1993). In the above discussion, we have tried to outline a framework that can be used to examine reforms that are initiated or controlled at different points in the intergovernmental system. For example, we have stressed that ambitious reforms typically involve new and challenging roles for everyone in the system—from state department officials to classroom teachers (David, 1993). Similarly, we have noted that the ambitious visions of reform must be shared by parents and community members as well as state legislators. Coherent policy is necessary at each level of the system: conflicting district policies on testing are just as damaging as such policies at the state level.

At the same time, our framework, consistent with most writing on systemic reform, does imply a directionality of influence in key components of the system. For example, the framework assumes that the ambitious goals for students and the general standards accompanying them are derived, or at least agreed on, at the larger levels of the system—typically the state. Similarly, technical and financial assistance often, though clearly not always, originate at higher levels of the system (state versus district, district versus school). In contrast, within this framework, we underscore the importance of flexibility and some control at the school and district levels. The framework also points to the importance of the participation and input of individuals throughout the system in shaping reform efforts.

In essence, then, the framework that is currently guiding our study does place a certain value on state direction of reform, but it is far from the traditional top-down perspective that guided the reforms of the 1970s and early 1980s (McLaughlin, 1987). And in fact, our initial fieldwork suggests that there are few instances of traditional top-down change efforts in the statewide systemic initiatives in which most major decisions are

made by a small group at the state level, nor are there initiatives that are controlled solely at the local level. Rather, as we discuss later, we have witnessed an array of approaches to reform marked as much by the diversity of interests involved as by any clear-cut control at either the state or local level. For example, it appears that extra-governmental teacher professional organizations and informal networks of teachers, concerned primarily with the content-specific issues in the reform of mathematics and science education, are playing a central role in these initiatives.

In sum, the purpose of this framework is to guide our data collection and our approach to analysis. The framework's value, then, will be tested by its usefulness in these tasks, especially in its ability to help us describe and distinguish among the state's various systemic initiatives in ways that allow us to explain differences in their development, and ultimately in the effects on the system of mathematics and science education.

Overview of First-Year Evaluation Activities

During the first year of our evaluation (1992-93), NSF had signed cooperative agreements with 20 states and Puerto Rico. We took a two-pronged approach to data collection. First, for all state initiatives, we conducted ongoing documentation of the progress of the initiatives through document review, and through telephone interviews where necessary. We also invited all state evaluators to an annual meeting and developed a working relationship with them through which we agreed to disseminate instruments and evaluation documents across the states. We assisted NSF in developing an annual reporting format and analyzed the results of those reports for the Foundation (Hawkins & Zucker, 1993). Finally, for all states we collected a set of statistical indicators on mathematics and science education (see also Shields, Zucker, & Hawkins, 1993).

Second, for a subset of nine states, we conducted more in-depth case studies, including week-long site visits to each state. These states were selected to represent a variety of educational and demographic contexts, as well as varying approaches to supporting systemic reform (Corcoran, Goertz, & Shields, 1992). The states are: California, Connecticut, Delaware, Kentucky, Michigan, Montana, Texas, Vermont, and Virginia. In the remaining years of the evaluation, we plan to continue these case studies, including examination of the effects of the state initiatives on a sample of districts and schools in each state. We will also be adding two new case study states from among the five recently chosen by NSF to receive SSI awards (Arkansas, Colorado, New Jersey, New York, and South Carolina).

Organization and Purpose of the Report

The purpose of this document is to describe the statewide systemic initiatives and to use this description to characterize different strategies for systemic change, to pinpoint areas for further data collection, and to raise key analytic questions that we will need to address in the second through fifth years of the evaluation. As such, we are not judging the value of different approaches. Our goal is primarily to describe and raise questions.

In the next chapter, we discuss the visions for improved teaching and learning driving the systemic initiatives and the broader reform efforts in which they are embedded. In the third chapter, we describe states' strategies for realizing their visions of change. We focus on which parts of the system are being targeted for reform and the theories of change underlying the states' approaches. In the fourth chapter, we describe the ways in which states have chosen to govern their systemic initiatives, raising questions about the potential strengths and weaknesses of each. We conclude with a discussion of the issues involved in measuring the success of NSF's SSI program.

2 VISIONS FOR CHANGE: SCIENTIFIC LITERACY AND MATHEMATICAL POWER FOR ALL[1]

Systemic reformers focus first on the creation of ambitious learning goals for all students, arguing that effective change must begin with a clear vision of the desired outcomes (Smith & O'Day, 1991). This vision, in turn, is meant to guide policy shifts throughout the educational system—ultimately sending a set of coherent messages to teachers and administrators about both what is expected and what needs to be improved to succeed.

In this chapter, we describe the visions guiding the reform of mathematics and science education in the SSI states. Looking across the states, we describe their goals for the improvement of mathematics and science education. We describe their similarities and differences, paying attention to the degree to which goals are embedded in frameworks and assessment systems and how equity issues are addressed. Finally, we raise a number of questions that we will seek to answer in the subsequent years of the evaluation.

Consistent with our overall approach to the evaluation of NSF's SSI program, we examine the statewide systemic initiatives and the visions driving them within the context of broader reforms in mathematics and science education in each state. Indeed, in many states, the goals of the systemic initiative are the same as those that state policy-makers had developed before NSF funding. California, Kentucky, and Vermont—all of which have ongoing, systemwide reform efforts under way—are cases in point. In these three states, one cannot consider the states' vision and goals separately from their all-encompassing reform agenda. In other states, the NSF-funded initiative has served as an impetus for the further development of goals for mathematics and science education reform. Montana and South Dakota provide examples here—in both instances, SSI has served to focus key individuals' efforts and to push along an ambitious reform agenda that otherwise might not have been possible. Nowhere are NSF-funded initiatives unaffected by the larger state reform context, although for some (e.g., Texas and Florida, where modifications to the SSIs are now being made), it appears that they have heretofore not been well integrated with other state reform efforts. Thus, in this chapter, in referring to

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[1] The title of this chapter has been borrowed from the Michigan State Systemic Initiative.

reform goals, we are generally discussing the broader statewide goals. When relevant, we note when and how the SSI fits into and supports this broader vision.

Visions for Change

Across the SSI states, there is remarkable consensus—at least on the surface—about goals for the teaching and learning of mathematics and science. These goals can be summed up succinctly in the phrase "scientific literacy and mathematical power for all." Packed into these words are a concern for both mathematics and science, a desire to see students come to value and to think critically across these content areas, and the aim that all students be able to apply their knowledge and skills to real-world situations. Importantly, the goal is to involve *all* students, not just that small percentage of high achievers in the mathematics and science pipeline. Given current levels of performance in mathematics and science, this is a remarkably ambitious goal. Michigan's vision statement provides a concise rendering of these general ideas:

> (1) To prepare *all* elementary and secondary students to become effective participants as workers and citizens in the 21st century.
>
> (2) *All* students will: (a) value mathematics and science and use them to make sense of their environment; (b) be able to communicate and reason mathematically and scientifically; (c) be able to apply rational, creative and critical thinking skills together with mathematics and science knowledge in order to participate responsibly in an increasingly technological society; and (d) know that mathematics and science are human enterprises that affect daily life. (Michigan Statewide Systemic Initiative, 1993)

These same ideas of the need for schooling to create productive and competent future workers and citizens are reflected in California's *Mathematics Frameworks:*

> All students should be expected to cope successfully with the mathematics they will encounter outside the classroom, including the increasingly sophisticated mathematics demanded in most jobs and most college courses. Also discussed in this Framework is the mathematics required for the exercise of competent citizenship in a democracy. Equally important, students should appreciate the beauty and fascination of mathematics and approach the mathematics they will encounter throughout their lives with curiosity, enjoyment, and confidence. (California State Department of Education, 1992)

This general agreement on the ultimate goals of mathematics and science education is much more firmly grounded in the case of mathematics education. It is rare that the

SSIs do not refer directly to the standards documents prepared by the National Council of Teachers of Mathematics: either the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) or the *Professional Standards for Teaching Mathematics* (NCTM, 1991), or both. In contrast, there is no set of national science standards. The National Research Council of the National Academy of Sciences is developing such a set, but it will not be completed until 1994, and there can be no assurance that the documents will be as popular and well accepted as the NCTM volumes. In the meantime, several different documents are the most frequently referenced by SSIs for science. One is the American Association for the Advancement of Science's *Science for All Americans* (AAAS, 1989). Another is the *Content Core* published by the National Science Teachers Association (NSTA, 1992). At one level, there is agreement in these documents that science should be given more prominence in the curriculum than it has had in the past; that students should learn concepts in greater depth, not simply memorize long lists of terms or facts; and that science should involve students in a wide variety of active learning experiences. But at other levels, such as lists of specific concepts or topics in science to be taught at specified grade levels, there is not yet a national consensus to nearly the same degree as there is in mathematics.

Whether in mathematics or in science, a national consensus will not mean that policy-makers, educators, mathematicians, and scientists in each state agree exactly about what children should learn, how they should learn it, and what efforts are needed to put the necessary changes in place. For example:

- In Montana, the vision of improved teaching and learning incorporates the use of technology to a much greater extent than in most other states' reform efforts.
- In Vermont, the state has committed itself to integrating the teaching and learning of mathematics and science at every grade level, in contrast to most states' efforts that retain in some formal sense the boundaries between the subjects.
- In Virginia, the state initiative's focus on mathematics and science runs counter to the broader state reform goals of promoting integration across all content areas.

That is, beneath the general rhetoric of the goals, differences often come to light. In the following section, we explore some of those differences, examining the degree of specificity in states' visions and how these visions are reflected in two key policies:

curriculum frameworks and assessments. We then examine how visions differ in their approach to equity issues.

What States Mean by Ambitious Learning Goals

In a number of the states involved in SSI, policy-makers have begun to rethink the entire vision of K-12 education (although such efforts typically started before participation in SSI). Illustrations of these efforts are found in the various *Common Core(s) of Learning* adopted in a number of northeastern states (Connecticut, Vermont, Maine) and in Kentucky's *Learning Goals*. For example, the Connecticut Board of Education adopted five statewide goals for education in 1990, addressing the general issues of "motivation to learn, mastery of the basic skills, acquisition of knowledge, competence of life skills, and understanding society's values" (Connecticut State Board of Education, 1991, p. 14). For each of these, the state enumerates several sub-goals. Under "acquisition of knowledge" are the following goals for students:

- Learn to communicate effectively in speech and writing.
- Listen, view, and read with understanding.
- Acquire knowledge of and ability in mathematics.
- Demonstrate skills necessary to locate and effectively use a variety of sources of information, including print materials, media, computers and other technology.
- Demonstrate decision-making, reasoning and problem-solving skills alone and in groups.
- Demonstrate good study skills and skills necessary for lifelong learning. (Connecticut State Board of Education, 1991, p. 14)

Such policy statements serve as a template against which specific statewide and local reform initiatives can be assessed. For example, in the general statements cited above, one finds clear support for group problem-solving, and thus for curricula that include opportunities for cooperative learning. Interestingly, however, science is not mentioned here.

Yet such broad policy statements can be so ambiguous that they do not provide local educators—especially classroom teachers—with sufficient guidance to change practice. Moreover, because of their generality, they need not address the tough issues related to specifying measurable outcomes or identifying methods for helping students to reach those

outcomes. For example, a common complaint heard after passage of Kentucky's landmark reform legislation in 1990 was that the state's ambitious learning goals were too ambiguous to help teachers accustomed to traditional teaching methods change their daily routines (Shields et al., 1993). The degree to which states have taken steps to make their visions more specific varies widely. Two typical policy instruments for doing so are curriculum frameworks and new assessment practices, as we discuss in the following sections.

Making Visions Real for Practitioners: Curriculum Frameworks

Curriculum frameworks are typically policy documents that, to some degree, provide advice on what should be taught. They may also provide advice on how topics should be taught, but this is much less frequent (Sutton, 1993). Indeed, what policy-makers mean by "frameworks" varies considerably across states. As Pechman and Laguarda (1993) note:

> State policy leaders use the terms "curriculum frameworks," "standards," "assessments," and "monitoring systems" according to specific, locally derived definitions... Moreover, interacting and rapidly shifting political, conceptual, and fiscal factors lead to regular and sometimes sudden modifications in the emerging systems and policies that guide them (pp. 2, 7).

At the same time, states use curriculum frameworks very differently. In Vermont, frameworks are meant only to guide local curriculum development; in California, they help to guide state textbook adoption, which has a powerful influence on content covered by teachers across the state.

At their best, frameworks provide teachers and school administrators with practical guidance for classroom-level, subject-specific improvements. As the concrete representation of the broader visions for reform, frameworks can serve as the basis for shifts in other policy areas (e.g., assessment and teacher preparation). As such, frameworks are often seen as the cornerstone of systemic reform, the "structure within which to organize the other important educational components" (Smith & O'Day, 1991, p. 248).

Many SSI states have followed this approach, complementing broader visions of reform with more specific recommendations embodied in frameworks. For example, in Vermont, where their *Common Core of Learning* was adopted by the State Board of Education in 1993, policy-makers are developing curriculum frameworks in most subject

areas. Kentucky, which put together its ambitious set of Learning Goals in 1990, just published its first set of curriculum frameworks in spring 1993.

California followed a somewhat different path, focusing from the outset on developing concrete frameworks with the goal of improving classroom teaching and learning. Consequently, California has been developing and revising frameworks for a decade now, creating documents that have served as models for many other states. The California frameworks provide excellent examples of concrete learning experiences that teachers can use. For example, at grades 2 and 3, the frameworks suggest that, in terms of attributes and classification:

> Students begin to classify things by two (and later three) overlapping attributes. For example, students may decide to overlap yarn circles (Venn diagram with one intersection) when they are sorting students into those wearing watches and those with brown eyes.... (California State Department of Education, 1992, p. 186)

In terms of understanding number and numeration at the same grade levels:

> Students count, compare, order, and estimate larger quantities. As they work with larger quantities, they group objects and investigate place value. They use fractions and decimals encountered in everyday situations. The students find halves (and other common fractions) of wholes and of groups.... (California State Department of Education, 1992, p. 186)

These examples illustrate the usefulness of frameworks for practitioners interested in what to do differently in their classrooms to improve mathematics and science learning. They also reflect the effort and substantive expertise that must go into the development of frameworks. Partly as a result of the capacity requirements and partly because of political considerations, many states do not yet have curriculum frameworks in place. In fact, only 6 of the 21 SSI states we examined this past year have implemented frameworks in both mathematics and science (Table 1).

Every SSI state, however, is moving forward with framework development—in many cases using SSI funds to support their efforts. Vermont, for example, is using a portion of its NSF funds to support the development of an integrated mathematics, science, and technology framework. What role the development of these frameworks will play in promoting systemic reform is a question that we do not yet have sufficient data to answer. We would expect different effects across the SSI states due to the wide variation

Table 1

MATHEMATICS AND SCIENCE CURRICULUM FRAMEWORKS: THE STATUS OF THE SSI STATES

State	Mathematics Curriculum Framework	Science Curriculum Framework
California	In place	In place
Connecticut	In place	In place
Delaware	Developing	Developing
Florida	Developing	Developing
Georgia	In place	In place
Kentucky	Developing	Developing
Louisiana	Developing	Developing
Maine	Developing	Developing
Massachusetts	Developing	Developing
Michigan	Developing	Developing
Montana	Developing	Developing
Nebraska	Developing	Developing
New Mexico	In place	In place
North Carolina	In place	In place
Ohio	Developing	Developing
Puerto Rico	Developing	Developing
Rhode Island	Developing	Developing
South Dakota	Developing	Developing
Texas	In place	In place
Vermont	Developing	Developing
Virginia	Developing	Developing

Sources: Pechman, E., and Laguarda, K., *Status of New State Curriculum Frameworks, Standards, Assessments, and Monitoring Systems* (Washington, DC: U.S. Department of Education, 1993); Blank, R., and Dalkilic, M., *State Policies on Science and Mathematics Education, 1992* (Washington, DC: Council of Chief State School Officers, 1993); interviews with selected state policy-makers.

both in the form of the frameworks and in their relationship to other elements of the education system (such as selection of instructional materials and assessment of student learning).

Making Visions Real for Practitioners: Assessment and Accountability

A second way policy-makers translate general visions for the improvement of mathematics and science into useful guidance for practitioners is through assessments. Well-designed and well-implemented assessment systems send a clear message to teachers, families, and students about what students should know and be able to do. In fact, one disjuncture in a number of states' systemic reform efforts is the mismatch between ambitious learning goals and the use of outdated assessment instruments that test an entirely different set of skills.

Like the development of high-quality curriculum frameworks, however, the creation of good and usable assessment instruments that accurately test what policy-makers want students to learn poses significant technical and political challenges. Many states are considering shifts from norm-referenced tests (that often focus too heavily on "basic skills") to more authentic assessments that require students to perform more complex tasks and construct their own responses. This pattern is reflected in Table 2, where we outline the current status of state assessment activities in mathematics and science. All SSI states sponsor testing programs in mathematics and the majority (15 of 21) sponsor science assessments. Less than half have alternative assessments in place in either subject area, but most are planning to implement some form of new testing program designed to measure students' deep understanding and ability to apply knowledge. Creating such instruments, however, raises difficult technical issues of sampling, the reliability of scoring procedures, and comparability. Such tests are also more costly to develop, administer, and score than conventional tests.

Kentucky is an example of a state that has placed assessment at the forefront of its systemic reform efforts. Here, performance-based assessment in mathematics, for example, was put in place in the spring of 1992 at three grade levels—a year before the state had published curriculum frameworks in the subject area. Kentucky also has embedded the new assessments in a high-stakes accountability system that establishes achievement targets for each school in the state and promises rewards or sanctions for schools reaching or not reaching those goals.

Table 2

STATE ASSESSMENT PROGRAMS IN MATHEMATICS AND SCIENCE

State	Math Achievement Test	Science Achievement Test	Math Competency/ Proficiency* Test	Science Competency/ Proficiency Test	Math Alternative Assessment	Science Alternative Assessment	Comments
California	Yes, California Learning Assessment System (CLAS) at grades 4, 8, 10	Planned at grades 5 (sample), 8, 10 Spring 1994	Yes, competency tests: end of course exams including the Golden State Exam and Career Technical Assessment Program	Yes, same as math	Yes, CLAS uses both content- and performance-based standards (grades 4, 8, 10)	Performance-based assessment developed and piloted. Implementation depending on funding	New assessment system has been developed and piloted
Connecticut	Yes, CT Mastery Test (CMT) in grades 4, 6, 8; CT Academic Performance Test (CAPT) in grade 10	Yes, CAPT in grade 10	No	No	Yes, extended response, open-ended items in CMT and CAPT; CAPT at grade 10	Yes, performance tasks on the CAPT	Piloting New Standards Project tasks; CAPT includes an interdisciplinary performance task
Delaware	Yes, performance-based, grades 3, 5, 8, 10, Riverside	No	No	No	Planning	Planning	

Table 2, Continued

State	Math Achievement Test	Science Achievement Test	Math Competency/ Proficiency Test	Science Competency/ Proficiency Test	Math Alternative Assessment	Science Alternative Assessment	Comments
Florida	Yes, norm-referenced test, grades 4, 7, 10	No	Yes, criterion-referenced graduation test in grade 11	No	Planning	Planning	
Georgia	Yes, ITBS, grades 2, 4, 7, 9	Yes, ITBS, grades 2, 4, 7, 9	Yes, competency test in grades 3, 5, 8; proficiency test in grade 11	Yes, competency test in grades 3, 5, 8; proficiency test in grade 11	Planning	Planning	
Kentucky	Yes, the Kentucky Instructional Results Information System (KIRIS) in grades 4, 8, 12	Yes, KIRIS in grades 4, 8, 12 (KIRIS is integrated across disciplines based on 75 learner outcomes)	No	No	Math portfolios in grades 4, 8, 12 and performance events; the high school portfolio will cover 4 years of work	Performance events in grades 4, 8, 12	KIRIS includes: (1) transitional (open-ended and multiple choice); (2) math portfolio; (3) performance events
Louisiana	Yes, CAT in grades 4, 6, 9	Yes, CAT in grades 4, 6, 9	Yes, competency test in grades 3, 5, 7; proficiency test in grade 10	Yes, proficiency test in grade 11	Yes, performance based 7th grade math assessment	No	
Maine	Yes, Maine Educational Assessment (MEA), grades 4, 8, 11	Yes, MEA, grades 4, 8, 11	No	No	Yes, grades 4, 8, 11, extended performance, extended multiple choice	Yes, grades 4, 8, 11, extended performance, extended multiple choice	MEA is 50% multiple choice and 50% performance assessment
Massachusetts	Yes, grades 4, 8, 12	Yes, grades 4, 8, 12	No	No	Yes, open-ended questions in grades 4, 8, 12	Yes, open-ended questions in grades 4, 8, 12	

Table 2, Continued

State	Math Achievement Test	Science Achievement Test	Math Competency/ Proficiency Test	Science Competency/ Proficiency Test	Math Alternative Assessment	Science Alternative Assessment	Comments
Michigan	Yes, Michigan Educational Assessment Program (MEAP) grades 4, 7, 10	Yes, MEAP in grades 5, 8, 11	Yes, students must pass MAEP in order to receive state-endorsed diploma (by 1995-96); new 10th grade proficiency test in 1997	Yes, students must pass MAEP in order to receive state-endorsed diploma (by 1995-96);	No	No	MAEP has three open-ended questions; designing new science MAEP
Montana	Yes, grades 3, 8, 11, state approved test at district's option	Yes, grades 3, 8, 11, state approved test at district's option	No	No	No	No	
Nebraska	Yes, 3 levels at district's option	Yes, 3 levels at district's option	Yes, competency test in grade 5 at district's option	No	No	No	Legislature has mandated a new accountability system by 1996
New Mexico	Yes, CTBS at grades 3, 5, 8	Yes, CTBS at grades 3, 5, 8	Yes, competency test in grade 10	Yes, competency test in grade 10	No	No	
North Carolina	Yes, grades 3, 6, 8	Yes, grades 3, 6, 8	Yes, competency test in grades 3, 6, 8, 10 and end of course proficiency tests for Algebra 1, 2, and Geometry	Yes, end of course proficiency tests for Physical Science, Biology, Chemistry, and Physics	Yes, enhanced multiple choice and open-ended questions piloted in grades 3-8	Yes, performance assessment and open-ended questions being developed and piloted in grades 3-8	

Table 2, Continued

State	Math Achievement Test	Science Achievement Test	Math Competency/ Proficiency Test	Science Competency/ Proficiency Test	Math Alternative Assessment	Science Alternative Assessment	Comments
Ohio	Yes, grades 4, 6, 8, 10; state approved test at district's option	No	Yes, competency test in grades 1-12, proficiency test in grade 9; proficiency test to be added in grade 12 (1994), grade 4 (1995), and grade 6 (1996)	No	No	No	
Puerto Rico	Yes, APRENDA grades 1-12	No	No	No	Early planning stage	Early planning stage	
Rhode Island	Yes, Metropolitan Achievement Test in grades 3, 6, 8, 10	No	No	No	Planning	Planning	
South Dakota	Yes, Stanford Achievement Test in grades 4, 8, 11	Yes, Stanford Achievement Test in grades 4, 8, 11	No	No	Yes, piloting performance assessment in grades 3, 5, 7, 9, 12	Yes, piloting performance assessment in grades 3, 5, 7, 9, 12	
Texas	Yes, Norm-Referenced Assessment Program for Texas, grades 3-11	Yes, grades 3-11	Yes, Texas Assessment of Academic Skills (TAAS); competency tests in grades 3, 5, 7, 9, 11	No	No	Yes, extended performance tests piloted in grades 4, 8, 12	State is planning performance items for all tests by 1994

Table 2, Concluded

State	Math Achievement Test	Science Achievement Test	Math Competency/ Proficiency Test	Science Competency/ Proficiency Test	Math Alternative Assessment	Science Alternative Assessment	Comments
Vermont	Yes, portfolios and open-ended questions in grades 4, 8 (matrix sampling)	No	No	No	Yes, for grades 4 and 8; piloting high school portfolios	New assessments being designed	Portfolio assessments are linked to NAEP
Virginia	Yes, Iowa Test of Basic Skills in grades 4, 8, 11	Yes, TAP in grades 4, 8, 11	Yes, Literacy Passport; proficiency test in grade 6	No	Designing alternative assessments, performance tests, and project assessments	Designing alternative assessments	Changes in political and educational leadership in the state under way

*Proficiency refers to tests that are used as criteria for allowing students to advance to the next level of schooling.

Sources: Pechman, E., and Laguarda, K., *Status of New State Curriculum Frameworks, Standards, Assessments, and Monitoring Systems* (Washington, DC: U.S. Department of Education, 1993); *State Student Assessment Program Database, 1992-1993* (Oak Brook, IL: North Central Regional Educational Laboratory and the Council of Chief State School Officers, 1993); Blank, R., and Dalkilic, M., *State Policies on Science and Mathematics Education, 1992* (Washington, DC: Council of Chief State School Officers, 1993); interviews with selected state policy-makers.

Kentucky's is an unusual case, however, because the political climate after a well-publicized state supreme court case allowed for a wholesale rethinking of the system of public education. Within that climate and at a time of relative economic prosperity, the state contracted with an outside firm to develop the new assessments at a cost of many millions of dollars, and the legislature was willing to mandate their use. South Dakota's and California's experiences provide better examples of the substantive, financial, and political challenges to putting high-quality assessments in place.

South Dakota traditionally is a local-control state with a relatively small state department of education. In this context, developing and implementing an innovative statewide assessment system would be quite difficult. Here the NSF-funded systemic initiative acquired a commercially developed performance-based assessment and implemented it in a series of pilot sites. This strategy circumvented the technical difficulties of developing a new instrument and the political issues of a state-mandated test in a local-control state—while providing a measure of student progress in schools and districts involved in reform activities.

California has had a tradition of strong state involvement in K-12 education, including a statewide testing program in place since the early 1970s. Yet, as the state's conception of high-quality mathematics and science education has evolved over the past few years, as reflected in the frameworks for mathematics and science, the state has struggled to keep pace with an appropriate assessment system. The state education department has developed and piloted a series of new assessments in both mathematics and science. For example, the department developed a performance-based science assessment at the 5th-grade level that was piloted in thousands of schools. Yet, in large part because of financial difficulties in the state, the formal state testing program (now called the California Learning Assessment System) has not yet received formal approval to launch the new science assessment statewide.

As with curriculum frameworks, questions are raised about the importance of assessment in systemic reform. Given the political, financial, and technical difficulties involved in developing and implementing new assessment systems, how far can we expect most states to proceed? Are performance-based assessments, which require hands-on, project-like activities that are holistically scored, the only viable assessment approach? To what extent must uniform instruments be in place statewide—what is the role of school- or district-developed assessment instruments? Can a new system of assessments be designed to serve varied purposes equally well, such as providing school- or district-level

accountability data to policy-makers as well as classroom-level information directly useful to teachers and students?

Visions for Equity

A central theme of systemic reformers is that ambitious learning goals need to be held for all students, not just the small percentage of high achievers committed to careers in mathematics and science (O'Day & Smith, 1993). Reformers argue that systemwide reform cannot be accomplished if large constituencies—the poor, urban school students, or women, for example—are excluded or are provided with schooling of low quality. More practically, reformers point out that the successful development of the nation's economy requires workers with fundamental numeracy, scientific literacy, and critical-thinking skills.

In response to such concerns, the NSF's SSI program explicitly requested that participating states seek ways to ensure that their systemic initiatives addressed equity issues. The SSI states have responded in various ways, depending in part on the demographic makeup of their schooling population. In some states, the issue of educating groups that have been historically underrepresented in mathematics and science careers is unavoidable. California, where more than 50% of the students in grades K-12 are from ethnic minority groups, provides the clearest example. Here, no reform initiative, especially in the elementary grades, can succeed without addressing the needs of limited- and non-English-proficient students. The California systemic initiative, recognizing the special needs of its student population, targeted its recruitment effort on the one-third of schools in the state with the highest enrollment of low-income students. The initiative also has invested in translations of its materials to ensure their availability to students in bilingual classrooms. Connecticut, which contains a number of economically impoverished urban centers, has taken a similar tack. The Connecticut SSI has targeted a significant portion of its funds on grants to "priority districts," all of which serve poor urban areas.

In other states, the target groups are different. In both South Dakota and Montana, science and mathematics reformers are concerned with access for Native American students, who traditionally have been tracked into lower-level courses. Thus, for example, Montana has included Native American communities in its pilot testing of new curriculum.

In some of the SSI states where there are not such clearly identifiable underrepresented groups, there have been significant debates over the best way to approach equity issues and even about which groups to target. In Kentucky, where a single city is the only location with an appreciable ethnic minority population, the SSI staff have formed an equity working group to assess how best to define and then serve underrepresented groups—here there is a special concern with isolated rural populations and with females. In Nebraska, which also has a relatively small ethnic minority population, the SSI staff have debated the appropriate target group—with a particular interest in focusing on opportunities for girls and young women in mathematics and science. A similar debate has arisen in Vermont—who should be targeted in working to provide more equal opportunities?

Equity at the Elementary Level: The Special Case of Chapter 1

One issue of concern is the relationship between SSI-sponsored reform efforts at the elementary level and the nature and quality of instruction provided to students in compensatory education programs, such as the federal Chapter 1 program. Chapter 1 itself is now a $7-billion program each year, and provides millions of students (predominantly in elementary schools) with supplementary mathematics instruction. Typically, the view of Chapter 1 mathematics is highly oriented toward "basic skills," which is in contrast to the goals of the SSI projects and to the recommendations of the mathematics education community (as embodied in the NCTM *Standards)*.

In one large SSI state that wants to increase the participation and achievement of underrepresented students, the mathematics supervisor reported that "Chapter 1 is becoming its own system, and they aren't playing the [SSI] game. The Chapter 1 world doesn't trust the reform world." At least in this state—and very likely in many others—the Chapter 1 administrators and teachers do not appear to be convinced that the "new" mathematics and science, as embodied in curriculum frameworks and materials, will result in improved learning for their students. Indeed, they may fear that the new standards and assessments may further disadvantage their students.

This issue is much larger than the SSI program. It will involve the pending reauthorization of Chapter 1 by Congress—and, more fundamentally, a basic rethinking of the goals of compensatory education and the use of compensatory funds by millions of administrators, teachers, parents, and even students. It also involves the examination and revision of public policies that have encouraged the tracking of students by academic

characteristics. If some portion of those in "the Chapter 1 world" are distrustful of the reform goals, another group that may be uncomfortable with the premises of some of the SSIs as they unfold are the parents of high-achieving students, who may see advantages in the current system of tracking. Respondents in many of the case study states indicated their doubts about the elimination of tracking, in part because they thought that many influential and active parents supported the concept. Related to this issue are fears on the part of these parents that new curriculum and assessment strategies, especially at the high school level, may disadvantage their children in the competition for places at selective colleges and universities.

Equity at the Secondary Level: Ambitious Learning Goals for All?

As states try to improve the teaching and learning of mathematics and science at the secondary level, reformers run up directly against a similar tradition of tracking, both across and within schools. Do ambitious learning goals for all students mean that all secondary students must be given the opportunity to learn the same content for the same period of time?

Such an approach would represent a radical departure from past practice. For example, how would a state committed to equity for all secondary students deal with vocational education? Would students in vocational schools, who generally are not planning to attend 4-year colleges, be expected (or at least offered the opportunity) to master the same content as their college-oriented peers in comprehensive high schools? Would such expectations be unrealistic, or, more worrisome to some, would such an approach lead to the watering down of opportunities and expectations for more advanced students? Would the complete elimination of tracking preclude the teaching of some advanced topics in mathematics and science? What are the implications for advanced placement courses?

For the group of SSI states targeting high schools, how to confront a traditionally tracked system is of paramount importance. Most states have not tackled this thorny issue directly yet, or are giving locals freedom to address it as they see fit. Some states are taking a proactive stance—for example, Delaware is actively involving all of its countywide vocational schools directly in its nascent reform efforts.

Montana has perhaps the most ambitious plan: to create a common high school mathematics curriculum for all students. The plan, directed through the state's systemic

initiative, is to develop four distinct levels (corresponding roughly to the 4 years of high school), each with a series of integrated (within mathematics) curricular modules. The intention is that all students in the state will have access to this one curriculum, thus eliminating formal tracking. Faced with the reality of unequal student interest, preparation, and ability, the reformers recognize that not all students will cover all four levels during their high school years. The goal is to ensure that all students at least make it through the second level—thus ensuring some common exposure to key mathematical ideas. To further accommodate student differences, it is also recognized that some students may take longer than 2 years to get through Level 2 work, so there are plans for a sequence as follows: Level 1, Level 1.5, Level 2. Thus, the plan seeks to provide equality of access, a common core of experience, and opportunities both for more advanced work and for slower movement through the core courses. The state's institutions of higher education (IHEs) have already agreed that 3 years of the new curriculum will satisfy college entrance requirements.

The Montana experience points to a possible solution to some of the thorny issues, but it also raises a number of key questions. Will all entering freshmen be prepared for Level 1? Does the program set some students up for failure? At the other extreme, will the program provide sufficiently challenging opportunities for higher-achieving students? These, of course, are the basic questions about any effort to provide simultaneously an ambitious and equitable academic program.

Summary and Questions

Across the SSI states, we find remarkable agreement on the general vision for high-quality mathematics and science teaching and learning—reflecting an emerging national consensus in these content areas. Not surprisingly, this agreement begins to disappear once we move beyond general statements and examine specific policies and practices. Even in those states that have sought to put their visions into practice, there is much controversy over the best approach. Montana and South Dakota have sought to implement new curricula directly into pilot classrooms and schools. Kentucky and Connecticut have used the leverage on state-mandated assessments to communicate their new visions for student learning. Vermont, through a great deal of local participation, has looked to change its entire system of education. All states face—and few have directly confronted—the challenge of providing equal, high-quality, and appropriate learning opportunities for all their students.

After the first year of our evaluation, we come away with more questions than answers concerning the difficult issues involved in developing statewide visions of ambitious learning goals for all students. In particular, we are interested in:

(1) The importance of state-developed curriculum frameworks and assessment systems. Are these the best tools to ensure that the vision of learning is adequately communicated throughout the system?

(2) Can ambitious visions be too ambitious? What happens when the state reform effort cannot live up to the expectations it has set? In Kentucky, the standards for world class achievement are extremely high—for how long will the public—and their representatives in the legislature—tolerate such a high "failure" rate?

(3) How can states provide equal opportunities to all students without either setting unreal expectations for some students or failing to challenge other students?

(4) How important is the process through which a state's vision is developed? In particular, how democratic must the process be to ensure broad acceptance of the new vision?

(5) How do states approach the different content areas? In particular, is science not considered a "basic" in the same way as mathematics?

(6) National standards in science are several years behind the mathematics standards. Will the SSI states accept the new science standards, and, if so, how much will visions need to change to accommodate the new standards?

(7) Will the vision of mathematical power and scientific literacy extend beyond the traditional academics to include vocational and technical education?

(8) Will states' visions for change effectively include reform of higher education (notably including preservice teacher education) as well as reform in grades K-12?

We will try to answer these questions in future years.

3 STRATEGIES FOR REFORM

This chapter provides preliminary information about characteristics of the statewide systemic initiatives and the strategies they are using to reform mathematics and science education. Based on data collected primarily from state-level stakeholders during the first year of the evaluation study, it begins the process of describing, comparing, and assessing the various strategies being used by the SSIs to achieve the ambitious goals we discussed in the preceding chapter of the report. The data presented in this chapter were collected in the initial round of fieldwork conducted in the nine case study states and from the annual reports submitted by all the states. The chapter addresses five basic questions about the SSIs:

(1) What do we know about the SSIs' approach to the reform of mathematics and science education, and how much do the approaches taken by the 21 states vary?

(2) How do the SSIs fit into the larger pattern of education reform in the states?

(3) From the perspective of our framework of systemic reform, what are the major strategies being used by the states to achieve policy coherence, build greater capacity for change, forge new and more productive relationships, and generate professional and public support for the desired changes?

(4) Given past experience with federal and state reform efforts, what factors would one expect to exercise significant influence on the progress and impact of the SSIs?

(5) Based on what is known and what might be predicted, what research questions should guide the next period of data collection?

Empirical "answers" to the first three questions, of course, are incomplete and inconclusive at this point in the evaluation study. The SSIs are too new for these questions to be wholly answered, and the data that are available are not fine-grained enough to assess all the important similarities and differences in the strategies being used across the 21 states. However, the data do raise more specific questions to be addressed in the next phases of fieldwork in the evaluation study.

Characteristics of the SSIs

The SSIs are partially defined by the subject areas they address, the grade levels they target, the size and scope of their activity relative to the statewide system, their focus on equity issues, and the patterns of their resource allocations. From these basic features of the SSIs, a general description of the SSI program begins to emerge. These descriptive data also suggest potentially important similarities and differences among the 21 SSIs. These characteristics are described below, drawing in part on data in the annual reports submitted by the principal investigators to NSF.

Disciplinary Emphasis within the SSIs

Are there any significant differences in the amount of attention being given to science and mathematics across the 21 states? The data from the state reports presented in Table 3 suggest that science and mathematics are receiving about equal attention in the SSIs. To date, one state initiative (Montana) has been addressing almost exclusively the reform of mathematics, and another (Florida) is focused only on science. The other 19 SSIs are addressing both subjects. These qualitative data about the focus of each SSI are consistent with fiscal data reported to NSF showing very nearly equal amounts of money from the Foundation being used for mathematics and for science.

Perhaps this pattern might have been expected since NSF strongly encouraged that both subjects be addressed. However, the relatively balanced attention being given to mathematics and science is noteworthy in light of the different stages of national standards in mathematics and in science, which might well have led to greater emphasis on mathematics during the initial years of the SSIs. Nonetheless, NSF's SSI program has been successful in stimulating roughly equal attention to the reform of science education and mathematics education.

The Levels of Education Being Addressed by the SSIs

In contrast to the apparent balance between mathematics and science, data on the grade levels being targeted by the SSIs (also shown in Table 3) suggest that different levels of the education system are being given differential attention. The elementary and middle grades are the principal foci of the SSI initiatives at this time, while high school education is receiving less attention (although in Montana, it is the only level of the K-12

Table 3

MAJOR FOCUS OF SSI INITIATIVES, 1992-93

	MATHEMATICS				SCIENCE			
STATE	Elem.	Middle	HS	Preservice Teacher Education	Elem.	Middle	HS	Preservice Teacher Education
CA		✔			✔			
CT	✔	✔		✔	✔	✔		✔
DE	✔	✔	✔		✔	✔	✔	
FL					✔	✔		✔
GA		✔		✔		✔		✔
KY		✔	✔	✔	✔	✔		✔
LA	✔	✔	✔		✔	✔	✔	
MA	✔	✔	✔	✔	✔	✔	✔	✔
ME	✔	✔	✔	✔	✔	✔	✔	✔
MI	✔	✔	✔	✔	✔	✔	✔	✔
MT			✔	✔				
NC	✔	✔	✔		✔	✔	✔	
NE	✔	✔	✔		✔	✔	✔	
NM	✔	✔			✔	✔		
OH		✔		✔		✔		✔
PR	✔	✔	✔	✔	✔	✔	✔	✔
RI	✔	✔			✔	✔		
SD	✔	✔	✔	✔	✔	✔	✔	✔
TX		✔				✔		
VA	✔	✔		✔	✔	✔		✔
VT	✔	✔	✔	✔	✔	✔	✔	✔

system being addressed). SSI state leaders forecast that nearly 12,000 elementary schools, more than 5,500 junior high or middle schools, and 2,700 high schools will have been substantially involved in the SSIs by the end of the fifth year. Three states expect no high school involvement in that period, and another four report that only a small number of high schools will participate.

The reasons for this lack of emphasis at the secondary level are not completely clear, but one can make some educated guesses. Many people believe that elementary and middle schools are in the greatest need of help; there is great concern about the amount of attention given to mathematics and (especially) science in the elementary grades and about the competence of elementary teachers in these subjects. Needs assessments in the SSI states apparently identified elementary and middle schools as priority areas for reform. On the positive side, most people believe that students' interests, skills, aspirations, and opportunities are heavily influenced by their experiences and successes in the lower grade levels. If no science is taught or if it is rotely taught and is boring, students will avoid it later on. If mathematics is poorly taught and students have difficulty with it, they come to feel that they are "not good at it" and avoid it later on. Changing this experience is especially important in raising the mathematics and science achievement of women and minorities.

Another possible, far less positive reason for the greater focus on middle and elementary schools is that high schools and the higher education system—institutions that are currently receiving less attention from the SSIs—are often considered to be more resistant to changes in pedagogy and curriculum than elementary and middle schools. If this is a factor, then, possibly, changes in student expectations and competence in the lower grades will generate pressure for reforms in the high schools and colleges later.

Another important factor in state designs to focus on particular grade levels is the limited resources available for development and improvement. This issue is discussed in the next section.

Resources and Local Participation

The Statewide Systemic Initiatives program lays out an ambitious reform agenda for the participating states and provides them with fiscal support that, although unusually large for an NSF initiative, is modest in contrast to state expenditures and the scope of the problems to be addressed. Consider that the expenditures on public education in 1989-90

for the 21 Cohort One and Two states amounted to about $91 billion (NCES, 1992), whereas their NSF/SSI budget in 1992-93 was $36 million, or less than .05% of their total education budget. This amounts to a nickel in SSI funds for each $100 of education expenditures in the participating states.

However, the NSF/SSI grants do represent a significant increase in the funds available to the states for research, development, and improvement; furthermore, the SSI budgets are purely discretionary. It is also important to note that NSF anticipates that SSI funds will be used to leverage the allocation and targeting of other federal, state, and local funds (e.g., Eisenhower funds) and private funds to support reforms in mathematics and science education. Thus, the SSI funds provide an important and unusual resource to the states. Nonetheless, their size relative to state budgets and student enrollments needs to be kept in mind when considering the possible impact in various states and the timelines for going to scale with curricular and pedagogical reforms.

The average size of the investment masks some large differences in the size of NSF's investment from state to state. Both California and Montana, for example, are receiving $2 million annually from the SSI program. In California, this amounts to about $0.40 per enrolled student in grades K-12; in Montana, the corresponding figure is about $18.00. It is not unreasonable to expect the SSIs with substantially greater amounts of money relative to population to be able to accomplish their goals more quickly than SSI states with smaller amounts. However, NSF staff believe that larger states have greater resources to call upon and that federal SSI funds should mainly act as a stimulus to leverage these resources.

Strategies for Going to Scale

One consequence of these resource constraints is that many states are limiting the numbers of participating schools and districts. For example, Michigan and Connecticut have chosen to work primarily with targeted urban districts, Virginia and California have chosen to focus on high-poverty districts, and Kentucky and Texas are developing demonstration sites. At this point, primarily smaller states, such as Delaware, Montana, and Vermont, envision significant statewide impact on schools within the 5-year time frame of the SSI.

Table 4 compares the number of districts targeted for participation in the SSIs, both now and in the future, with the total number of districts in the participating states. The

state SSI principal investigators forecast that more than 65% of the districts in the 21 states will participate directly in some SSI activity during the 5 years of funding. These data suggest that the SSI program has a significant scope of action, but also that the efforts will have to be sustained long beyond the funding period to achieve the goals of universal improvement.

Table 4

INVOLVEMENT OF DISTRICTS

	Total Districts in SSI States	Total Districts Involved to Date	Total Districts Expected to Be Involved Over 5 Years of SSI
Cohort 1	2,907	755 (26%)	2,125 (73%)
Cohort 2	4,012	938 (23%)	2,400 (60%)

N = 21.

Source: NSF Annual Reports, 1993, Items A1 and A2.

However, these figures do not tell the full story of the potential impacts of SSIs. It is likely that in many districts the impacts will be partial: only certain grade levels, subjects, or schools will be affected. On the other hand, many nonparticipating districts may adopt or adapt the curriculum, assessment, and pedagogical reforms associated with SSIs, and this will increase the percentage of districts and schools affected. Many states expect that, as the momentum for reform builds, pressure from parents and teachers, the activities of professional associations, and state actions with regard to curriculum, assessment, teacher certification, and other policies are likely to generate pressures for "voluntary" local adoption of the reforms.

Typically, after initial planning is complete, states are beginning their SSIs on a small scale with the expectation that they will grow larger over time. The plans for this growth vary from one state to another. For example, the main mechanism in Montana is a single, large curriculum development project that has begun to be implemented in pilot schools and classrooms, and ultimately is expected to reach many or all of the high schools in the

state (and perhaps some out of state, as well). By contrast, in states such as Connecticut, Michigan, and South Dakota, the major mechanisms for local diffusion will be a succession of grant competitions open to districts within the state; as more awards are made over time, the SSI initiative grows. The distribution of these different "models" or mechanisms of diffusion is provided in Table 5.

State policy initiatives consistent with the SSI could also dramatically enhance its impact. For example, if a state changes teacher certification or recertification requirements or its assessment program, then *every* district in the state would be affected, although all the districts would not necessarily be "directly involved" in the SSI. Or, if the SSI initiative helps states in developing new alliances among varied institutions and organizations, these accomplishments might extend the impact of the initiative. Nonetheless, policy-makers must realize that the SSI program is not likely to touch every student in the participating states, or even directly reach every student's teacher. The available funds simply will not permit this level of impact.

Allocations of SSI Funds

Table 6 displays how the NSF SSI funds have been allocated across major domains of activity during the past year. The table shows that nearly 30% of the total SSI budget was allocated to inservice education, which constituted the single largest category of spending last year. What may be somewhat surprising for an initiative that is often characterized as "standards-driven" reform is that only 4% of the total was allocated to framework development and only 6% to assessment (which is generally too expensive for SSI to handle the costs). Part of the explanation may be that many of the SSI states already have frameworks or are using state (or other federal) funds to develop them. Similarly, states themselves may be paying for the development of new performance assessment systems. Another part of the explanation is that much of the work going into framework development is being volunteered by teachers and faculty or being paid for by their institutions.

Table 5

PRIMARY SSI MECHANISMS FOR IMPLEMENTATION AND DIFFUSION
1992-93

State	Lead Teachers	School Teams	Pilot or Demonstration Schools	District/ Local Grants	Regional Centers	Distance Learning or Technology Networks	Curriculum Frameworks	Curriculum Units	Teacher Preservice	New Partnerships
CA	✔	✔								
CT				✔					✔	✔
DE		✔	✔				✔	✔		
FL	✔	✔	✔		✔		✔			
GA			✔				✔		✔	✔
KY	✔		✔		✔				✔	✔
LA				✔	✔					✔
MA	✔	✔	✔			✔			✔	✔
ME			✔				✔		✔	✔
MI				✔					✔	
MT	✔		✔	✔				✔		
NC	✔				✔				✔	✔
NE	✔					✔				✔
NM	✔				✔				✔	✔
OH	✔				✔					✔
PR		✔	✔			✔			✔	✔
RI		✔			✔		✔			
SD				✔		✔				✔
TX			✔		✔	✔				
VA	✔	✔		✔		✔			✔	
VT		✔		✔		✔	✔			

Table 6

PERCENTAGE OF NSF SSI EXPENDITURES BY PURPOSE

Category	Amount
Frameworks	4%
Curriculum/science	4
Curriculum/math	6
Assessment/science	3
Assessment/math	3
Inservice/science	15
Inservice/math	13
Preservice/science	3
Preservice/math	2
Public awareness	5
Steering committee	4
Administration/coordination	16
Evaluation	4
Grants to locals*	13
Other	6

N = 21.

* These funds were also used for inservice, curriculum development, assessment, and similar purposes, but at the district or school level.

Source: NSF Annual Reports, 1993, Item B2.

The NSF funds are not the only ones being used to support the SSI initiatives. Table 7 shows that the states were successful in finding more than a 100% "match" in other monies for the approximately $36 million provided by NSF. An additional $57.4 million above and beyond NSF funds was raised by the states, according to the figures they provided to NSF. Table 7 also shows that, whereas the SSIs are having success leveraging other state and federal funds, they have had little success raising private funds.

Table 7

FUNDS FOR SSI FROM SOURCES OTHER THAN NSF

Source	Amount	Percent of Total
Eisenhower/District funds	$14,168,646	24.7%
Eisenhower/Higher education	6,712,256	11.7
Eisenhower national curriculum grant	556,710	1.0
Other U.S. Dept. of Ed. funds	3,313,839	5.8
Other NSF grants	5,067,616	8.8
Funds from other federal agencies	62,842	0.1
State funds	19,424,829	33.8
Private foundation grants	794,080	1.4
Other	7,307,531	12.7
Total	$57,408,349	100.0%

N = 21.

Source: NSF Annual Reports, 1993, Item C2.

Integration with Other Reform Initiatives

The recent history of the 21 states participating in the SSI program is remarkably varied in terms of the extent and the nature of school reform efforts under way before the initiation of SSI. In a period marked by a high level of state reform activity, some states have been more aggressive than others in pursuing statewide reforms in general, and in science and mathematics education in particular. To understand the implementation and the impact of the SSI program, it is important to keep this "bigger picture" of education reform in mind.

If states were placed on a continuum representing the scope of their reforms apart from the SSI, California, Kentucky, and Vermont would be among those states near the most active end, with many other reform activities under way. States like South Dakota

and Louisiana would be closer to the other end of the continuum, having supported relatively little else in the way of widespread education reform, while a number of states, including Delaware, would fall somewhere in the middle. Examining the impacts of SSI in these varied contexts requires some understanding of the states' histories.

In the states with a lengthy history of reform, SSI is typically an important piece of a broader state school reform strategy, but it is only a piece. SSI was not the catalyst for reform in these states, nor did it determine the direction of change, even in science and mathematics education. The challenge is not simply to stimulate change in mathematics and science education, but to integrate those changes with other state and local reforms. Several examples illustrate this situation.

- **Kentucky.** Kentucky's SSI, called the Partnership for Reform Initiatives in Science and Mathematics (PRISM), is highly integrated with a comprehensive education reform initiative that resulted from a state supreme court decision in a 1990 school finance case. The Kentucky Education Reform Act (KERA), which was the General Assembly's response to the court decision, set forth a bold plan for restructuring the public education system in *all* disciplines. KERA provides both an opportunity and a challenge for the SSI leadership. The opportunity is created by the new statewide curricular frameworks required by KERA and the implementation of high-stakes assessments that include both mathematics and science. However, the greatest challenge facing PRISM is to persuade teachers to change their pedagogical approach in these fields (e.g., to use calculators and computers more extensively) at the same time they are being asked to cope with KERA's changes in standards, curricula, school organization, and the results of high-stakes testing.

- **California.** Since the early 1980s, the State Department of Education has been far ahead of most states in rethinking mathematics and science education, and in devising various initiatives to support reform in these subject areas. Unquestionably, the leadership group in the state had a vision of systemic reform long before it was fashionable. However, some pieces of the reform puzzle (curriculum frameworks, for example) have been much more fully developed than others (e.g., the state assessment system). Because California was engaged in "systemic" reform before the SSI award was made, the SSI funds have been used to fill gaps not adequately funded from other sources. Thus, although the SSI in California focuses on professional development in support of elementary science and middle school mathematics, it would be wrong to conclude that the state has ignored the development of frameworks or assessment or neglected elementary mathematics.

- **Vermont.** Vermont's policy-makers are committed to a systemic approach to reform and to the restructuring of the public schools. They believe that Vermont

> is the perfect "test laboratory" because of its small size. They understand systemic reform as a set of linked changes based on a common vision of public education that is consensually developed. These changes are voluntarily undertaken by local schools and supported by the state. The key elements are the Common Core of Learning, which defines the vision, and a pervasive instructional guidance system of curriculum frameworks and authentic student assessment, professional development, school restructuring, school-community partnerships, service integration, and expanded technical education. The SSI is pursuing a strategy consistent with Vermont's traditions and with the broader reform initiative. It is assisting with development of the instructional guidance mechanisms and preparing school and community teams as the catalysts for grass-roots change.

In cases such as these, simply tracking the expenditure of SSI funds, or narrowly examining the impact of SSI activities, can be misleading because the SSIs are intentionally embedded in larger initiatives. The data must be understood in this larger context, which is both more comprehensive and more complex. The vision, energy, authority, and funds for reform come from different sources than in other SSIs; there is a history to the initiatives; and effects on schools and classrooms cannot be easily attributed to any single program or policy.

At the other end of the continuum of reform efforts are states like South Dakota and Louisiana, where the SSIs have served as catalysts for reform. This is not to say that there have been no reforms in these states since the early 1980s. However, the reform efforts have been less systemic and less coherent than those initiated in Kentucky, California, and Vermont. In states in which the SSI serves as the catalyst for systemic reform, its effects may loom larger and may be easier to isolate and track. At the same time, however, it is not by any means assured that the SSI will be sufficient in size and scope in these states to stimulate and sustain broader-scale reforms. Beginning mathematics and science education reform without a strong foundation of prior efforts to build on may be a serious handicap.

Some states, which can be placed in the middle of the continuum, currently have a much larger set of reforms under way, but these are of recent origin. Delaware is such a state. A reform effort is under way there that is as broadly based as that in, say, California; however, this effort postdates the SSI award. The leadership in Delaware has pulled together a variety of preexisting reform strategies under a single reform agenda called New Directions for Education in Delaware. The SSI will serve as the development

arm of this effort, supporting the implementation of new strategies for curriculum and instruction in mathematics and science at the local level.

In a few states, there is a question whether the SSI is, in some real sense, standing apart from or even potentially in conflict with other reform efforts. There is some evidence that this is the case, for example, in Virginia and in North Carolina. In Virginia, the state has recently adopted a view of curriculum and instruction that minimizes emphasis on the subject disciplines; mathematics and science are no longer departments or organizing principles in the state education agency. This approach leads to concerns about how well the SSI fits with the state's overall reform strategy. In North Carolina, the potential clash is of a different kind, based on the fact that a new regional structure has been created to support the SSI even though the state in the past supported at least two regional networks. Forming these several networks into a cohesive whole is proving difficult.

Federal policy-makers need to realize that isolating the impacts of the program in the larger context of reform may be difficult. The program does not exist in a vacuum and in some instances may be supporting only particular facets of a broader state reform effort. It needs to be understood in a context that involves a wide variety of reform efforts, not only at the state level but at the federal level as well. It may turn out, for example, that the SSI is effective in some states precisely because it has been well timed to coincide with a variety of other reform efforts, or, alternatively, it may be that the SSI has its greatest impact in states where it serves to stimulate broader reforms that were previously absent.

Reform Strategies in the SSI States

Policy Coherence and Policy Choices

Much has been written about the importance of policy coherence; it is one of the core concepts in systemic reform. Smith and O'Day's (1991) vision of systemic reform pairs ambitious, coordinated state policies with restructured governance. The logic of systemic reform is that coordination of key state policies will provide more coherent guidance to practitioners, and have more powerful effects on instruction. While states differ in the range of policies they attempt to coordinate, the generally accepted view is that the minimum set of essential policies includes state goals or vision, curriculum frameworks, assessment, and teacher preparation (Fuhrman & Massell, 1992, p. 4). Some of the SSI states, such as California, Kentucky, and Vermont, have worked hard to create

coherent policies that send consistent signals to the field and have a reinforcing, multiplier effect on reform initiatives. Others, such as Michigan, are engaged in comprehensive reviews of policies to determine how well they fit together. In many of the SSIs, the collaboration among many interests (including the state education agency, higher education, the governor's office, the legislature, education interest groups, business, and civic organizations) focuses attention on issues of policy coordination and creates pressures for greater coherence. Whether formal or informal, newly created or long-standing, the collaborations among state-level agencies and institutions may play critical roles in creating a policy environment that supports systemic reform.

Some states, such as California and Kentucky, already have tightly coordinated, centralized policies and are using the SSIs to move their initiatives forward. Others, such as Vermont and Connecticut, are highly coordinated but, consistent with their political traditions, are less prescriptive and less tightly coupled. Some, such as Delaware, Texas, and Virginia, are moving toward development of more coherent policies and integration of the SSIs, although the movement is not always smooth and consensual. Still others, like Michigan and Montana, have not developed a statewide approach based on a coherent set of policies, and the SSIs there may serve as the catalyst for a more systemic approach.

Some quantitative information about the main focus of the 21 SSIs is available from the survey of SSI principal investigators conducted by NSF. Table 8 shows the number of states spending 10% or more of their SSI budget during the past year on selected components of systemic reform. Using this criterion, the most common activity supported by SSIs was teacher professional development, with curriculum development the next most common. It should be noted, however, that money is not necessarily the only metric worth using; for example, it might require little SSI money to change a state's teacher certification requirements, yet the impacts might be great.

Much has been written about the need for coherence, but less attention has been given to the choice of policy instruments to lead reform and to the examination of which instruments are likely to be most effective in bringing about the changes in pedagogy and curriculum necessary to meet the challenging standards envisioned in systemic reform. McDonnell and Elmore (1987) have suggested that a limited set of policy instruments are available to promote reform: mandates, inducements, capacity building, and system changing. A fifth category, mobilization of public opinion, probably should be added to these four. McDonnell and Elmore argue that the choice of policy instruments affects the

Table 8

MAIN FOCI OF THE SSI INITIATIVES*

State	Teacher Inservice	Curriculum Development	Frameworks & Standards	Student Assessment	Teacher Preservice	Public Awareness	Awards to LEAs**
CA	✔					✔	
CT	✔	✔					
DE	✔	✔					✔
FL	✔						✔
GA	✔				✔		
KY	✔	✔			✔	✔	
LA	✔						
MA	✔				✔		
ME	✔						✔
MI						✔	✔
MT	✔	✔					
NC	✔						
NE	✔	✔				✔	
NM	✔						✔
OH	✔	✔					
PR	✔	✔					✔
RI							✔
SD		✔		✔			✔
TX	✔	✔		✔			
VA	✔			✔	✔		
VT	✔	✔		✔	✔		✔

* ✔ Means the state spent 10% or more of the SSI funds on this category during the past year.
**LEAs = local education agencies.

Source: NSF Annual Report, 1993, Item B2.

impact of reform initiatives, and that more needs to be known about how these different instruments work, given variation in purposes, contexts, local capacities, etc.

In only a handful of SSI states—California and Texas (instructional materials), Kentucky and Puerto Rico (frameworks), and possibly in the future, Delaware (standards) and Kentucky and South Dakota (performance testing)—do state mandates appear to be playing significant roles in the implementation of the SSIs. And, with the possible exceptions of South Dakota and Delaware, the use of mandates in these cases does not represent any change in traditional state-local relationships.

Inducements of various types (grants and publicity, to name two) together with capacity-building activities (such as professional development) are the preferred tools of implementation. All the SSIs are using inducements in some form to persuade local policy-makers and teachers to undertake reforms in curriculum and pedagogy. In a subsequent report, we expect to discuss these various inducements in greater detail. Capacity building and systems changing are so important to the SSIs that they are discussed separately below.

Building Capacity

Teachers and administrators need to believe that the reforms advocated in the SSIs are possible and that they are capable of implementing them. They must believe that the intellectual, time, fiscal, and political constraints to the changes in teaching and curriculum can be overcome. New forms of support will be needed. If every teacher must become more expert in teaching mathematics and science, then an extraordinary professional development effort will be needed. If teachers are expected to teach "hands-on" mathematics and science, then good materials must be accessible, and they must be replenished. School resources will need enrichment or reallocation to support more laboratory work and field trips.

Undoubtedly the most common focus of the SSIs is mobilizing professional networks and improving the capacity of the education system to deliver high-quality instruction in mathematics and science. This includes such activities as providing teachers with professional development services (inservice), developing and implementing new curriculum materials, and building networks of model or pilot schools and programs.

Demonstration Sites and Pilots. One strategy for building capacity is the development of demonstration sites. Georgia, Kentucky, Maine, Massachusetts, Michigan, Montana, Puerto Rico, South Dakota, and Texas are using this strategy. Demonstrations can provide solid evidence that reforms are feasible, and provide opportunities for observation and hands-on learning for teachers. Given adequate resources, they can serve as effective regional training institutions. They provide visible examples of progress for the public and can help generate public demand for reform. However, they also can inhibit reform if they are perceived as being given excessive funds or special treatment by the state. Demonstration sites have been often used as reform strategies, but have not always proved very effective because reforms tend not to spread to other sites. They may be much more powerful when combined with the other policy instruments employed in a systemic initiative.

Teachers as Trainers. Turnkey training is another popular strategy for dissemination of new practices. A number of states are using turnkey trainers or lead teachers. Kentucky is preparing cadres of teachers to serve as trainers for elementary and middle school mathematics and science and for technology. Virginia is training lead teachers, two from each participating school, to introduce reforms to their peers. They also provide training for school administrators. California also trains pairs of teachers from participating schools, but supports them with a network of consultants. Vermont is offering training to school teams, including principals.

The success of these lead teacher or teacher-trainer models may depend not only on the quality of the training but on the amount of time they have to work with their peers, the opportunities for continued interaction with other colleagues who experienced the training, the continuation of the training through booster sessions, the critical mass of committed and trained teachers in a school or a district, and the availability of materials. Some of the states are addressing some of these conditions; few appear to be addressing them all. Above and beyond qualified trainers, school and district leadership will be needed and must be encouraged by the SSIs.

Professional Development. All the SSI states are making heavy commitments to professional development. Some are emphasizing lead teachers or school teams, as described above. Others are offering programs for individuals. This focus on professional development reflects two general findings from the research on reform. First, many teachers, especially elementary and middle school teachers, lack the subject-matter knowledge needed to teach to the new standards (Shields et al., 1993). Second, existing

structures for professional development may not be adequate to the task of providing teachers with the needed assistance. Not only is the current system fragmented, underfunded, and poor in quality, but the very approach taken—training programs intended to transmit knowledge—does not fit the demands of current reforms (Little, 1993). In response to these shortcomings, new models of professional development are emerging, such as subject-area collaboratives and teacher networks, professional development schools, and partnerships between schools and colleges that recognize the expertise of teachers and provide opportunities for dialogue, exploration, and critique among teachers and between teachers and others involved in reforms.

Some of the SSIs are experimenting with similarly creative approaches. Vermont has developed regional networks of teachers to implement its portfolio assessment, and is using the scoring of the portfolios as a major opportunity for professional development. Delaware is working with school teams who are leading school restructuring efforts. Professional associations are playing important roles in Connecticut, Montana, and Nebraska. Ohio is pairing teachers with scientists from the business sector. Many states are running summer institutes for teachers that bring together content experts and teachers in a collegial setting. These new approaches bear close monitoring to determine whether they are more cost-effective than the workshop model so commonly used by states and school districts.

Mobilization of Support

One of the major obstacles to curriculum reform is public acceptance of the need for change and support for the envisioned reforms. Although there is general dissatisfaction with public education, parents across the nation remain satisfied with the schools that their children attend (Elam, Rose, & Gallup, 1992). Gallup Poll results also show that fewer than a quarter of Americans are even aware that there is a national goal for American students to become first in the world in mathematics and science achievement by the year 2000 (Elam, Rose, & Gallup, 1992). Moreover, when asked to rate the importance of the national education goals, they do not rate this one especially high (Elam, Rose, & Gallup, 1991). There is some evidence that the public simply does not see the same need for higher academic standards and more rigorous curriculum that the policy community and business leaders see, but feels instead that students need to master the basic skills and learn more discipline to be competitive in the workplace (Public Agenda Report, 1990). The

importance of public awareness and support is often underestimated by reformers, who may believe that "everyone" accepts the importance of mathematics and science education.

Added to this general problem of public lack of understanding or lack of support for high standards are the debates over "values" in the curriculum being raised by religious leaders and conservatives. This grass-roots opposition to reforms can be a particular problem for science education in a number of states. Finally, there is the underlying problem of who pays for reforms. In many states, the voter backlash against higher state and local taxes remains a powerful force. As the number of households with school children declines, the willingness of the electorate to support school reforms grows more problematic.

Recognition of the need for building public support for sustained reform has given rise to one of the unique aspects of the SSIs: public relations campaigns on behalf of the reform of mathematics and science education. Many of the SSIs are developing and implementing such campaigns. This focus is a potentially important contribution of the SSI program as a whole. Few if any other federal programs for school reform have mobilized such a wide variety of institutions (e.g., public and commercial television stations and newspapers) to focus on public awareness of the need to improve science and mathematics education.

Four states (California, Kentucky, Michigan, and Nebraska) report allocating more than 10% of their funds to public awareness. One of our case study states, Connecticut, allocated about 8% but has persuaded public relations firms, newspapers, and television stations to make in-kind contributions and lower their fees to mount an ambitious media campaign. This may be essential to their success because, as one observer in Connecticut noted, "there is little public demand for school reform ... unless it would be to reduce the costs of the schools or to lower teachers' salaries." The findings in this high-tech state are more stark than in many others, but taken together with data such as cited above, it is clear that continuing emphasis on public awareness and support will be vital. The states are still looking for the best vehicles to reach the public; California had planned a large statewide campaign, but on the advice of its program staff has reconsidered focusing its efforts on school-level publicity.

Changing Roles and Relationships

Smith and O'Day (1991) and other advocates of systemic reform argue for a combination of state instructional leadership and guidance and school-level discretion and empowerment. Curriculum control policies are the easiest policies to implement. The instruments—frameworks, state assessments, materials, and professional development—can be coordinated by the state and put into place. Finding the balance between these forms of state guidance and empowerment at the school level is more difficult. State policy-makers usually prefer control strategies because they seem cheaper, quicker, and more certain. The experience with the basic skills movement suggests that they can be effective, but they may not work as well in areas where teachers are less sure of their technical competence. Advocates of empowerment strategies emphasize the need for commitment to ensure local implementation. Empowerment strategies usually assume that teachers will develop curriculum, and that they will make the right choices. In general, the SSI states have not addressed the questions about authority relationships raised by Smith and O'Day. Kentucky is the only SSI state that has radically altered school governance and moved responsibility for curriculum to the school level. However, the stakes are high and it is not yet clear that Kentucky's approach will work well. Ironically, it also has one of the most powerful and most prescriptive instructional guidance systems. Delaware is also engaged in school restructuring and is moving in the direction of more school-level decision-making.

Teachers are being asked to play new roles in a number of the states, although these efforts fall short of comprehensive restructuring. Virginia is relying heavily on a lead teacher strategy, training two teachers in each school to help their peers implement the reforms. California is using a similar strategy. Kentucky is following a turnkey training model, preparing cadres of teachers to support reforms in mathematics, science, and technology. Vermont is training and supporting networks of teachers who work together to implement and score the mathematics portfolios. Puerto Rico is trying to promote more independence among teachers in developing their own curriculum materials.

Some SSI states are forging new relationships between the colleges and the schools. Connecticut is giving grants to create dialogues between faculty and teachers, encourage co-teaching, and support partnerships for inservice. Kentucky is building its technical assistance structure around eight regional universities. On the whole, however, the reform of higher education (including teacher preparation) is receiving only modest attention under the SSI.

Lessons from Previous Experience with School Reform

There is a rich literature on implementation, innovation, and planned change in education. On the basis of these studies, Fuhrman and her colleagues made a set of forecasts about the factors that would affect the outcomes of state reforms in the 1990s (Fuhrman, Clune, & Elmore, 1991). Based on their work and other recent reviews of the implementation literature, a similar set of predictions might be made about the anticipated course of federally funded state reform initiatives (McLaughlin, 1991; Marsh & Odden, 1991). These predictions might go as follows:

- Variations in state context will produce wide variation in the choice of policy instruments and strategies; states will focus on those aspects of the SSI agenda that best fit their goals, political climate, and capacity.
- The most ambitious efforts will have the most effect.
- Success in changing pedagogy and curriculum will depend heavily on the extent to which teachers are competent to make the desired changes. Acceptance by teachers and implementation will be enhanced by high-quality preparation, interaction with other teachers, and external assistance.
- Active commitment of district and site leadership will be critical to successful implementation and institutionalization.
- Implementation success will be enhanced to the extent that the reforms delivered clear, coherent signals to local districts and schools.
- The implementation process will be enhanced to the extent that local actors were involved in shaping the reforms, planning the strategies, and assisting with development.
- High-quality materials will enhance the possibilities of successful implementation of new practices.

These earlier findings suggest a number of hypotheses about the SSIs that should be considered as the evaluation study continues to examine local implementation. However, these propositions may not hold true to the same degree, or they may not turn out to be the most important factors shaping the outcomes of the SSIs. The SSIs represent a departure from previous state and federal attempts to improve public education. They are not narrow efforts to develop new curriculum; nor do they focus exclusively on a particular student population. Unlike most previous programmatic efforts to improve the schools, they seek the mobilization of political, fiscal, and human capacity in the states on

behalf of fundamental and broad-based changes in teaching and learning for all students with regard to science and mathematics education. Therefore, the lessons drawn from past studies of state and federal reform efforts offer only limited guidance for anticipating the unfolding of these new initiatives. As a consequence, it is important to accurately document and describe these initiatives in the states, and not permit predictions drawn from previous research to narrow the data collection.

We sum up this chapter with a series of questions we will want to address as our study continues during the next 4 years:

- There are a variety of alternative strategies for approaching systemic reform. How do they differ? Why do states select them? Under what conditions do they work best?
- States have made a wide variety of choices in balancing the breadth of their SSI initiatives (i.e., a larger number of grades and subjects) with greater depth. What are the relative payoffs of these different approaches?
- States enter the SSI program with very different histories of implementing education reform. What is the difference in "value added" by SSI in states that already have extensive reforms under way compared with those that have few?
- What balance do the states achieve between top-down, prescriptive strategies, and bottom-up, empowering strategies? What factors affect this balance? How does the relative mix of these strategies affect the pace of diffusion and the impact of the SSI?
- What factors contribute to the development of local policy coherence and support for the reforms in teaching and curriculum envisioned by the SSI?
- Is school restructuring necessary to achieve the curricular and pedagogical goals of the SSI?
- What are the interactions between the SSI and a variety of other unfolding reform efforts, such as the reauthorization and possible redesign of the Chapter 1 program?

4 THE GOVERNANCE OF STATEWIDE SYSTEMIC INITIATIVES: BUILDING COLLABORATION, CONSENSUS, AND COHERENCE

Advocates of systemic reform call for more challenging standards for all students, significant changes in curriculum and pedagogy, new assessments of performance, and revisions in teacher preparation and certification, among other fundamental changes to the educational system. Such a vision requires, at a minimum, *consensus* on standards among policy-makers, practitioners, and the public; more *coordinated and coherent* policies across agencies and across levels of government; the *collaboration* of public, private, and professional organizations; and the *cooperation* and *commitment* of state and local policy-makers and practitioners to achieve the necessary changes in schools. NSF's Statewide Systemic Initiatives program explicitly recognizes these challenges and calls directly for states to form effective partnerships among the key players in the mathematics and science communities—in government, universities, and the K-12 system. The logic here is that systemic reform's demands for consensus and coherence are likely to require new partnerships and relationships throughout the educational system.

How statewide systemic initiatives choose to organize and govern themselves may determine, in part, how well they can meet these challenges. The nature of the governance structures of the SSIs might affect their capacity to develop consensus, achieve coherence, convince various groups and organizations to collaborate, and win the cooperation and commitment of stakeholders at all levels of the education system. In short, an effective governance structure may enable the initiative to become truly systemic, to be fully implemented, and to persist in spite of changing political leadership or priorities. A weak or ineffective governance structure may doom an SSI to the same small impact and short life cycle as those of many other improvement projects.

In this section of the report, we look at the structure and process that systemic initiative staff use to formulate policy, allocate resources, and set the goals, priorities, and strategies for the SSI. We examine who makes decisions, the processes used to make decisions, and who is accountable to whom for carrying them out. Here we address only governance issues at the state level, where we focused our data collection during the evaluation's first year. In subsequent years, we will look more closely at the organization and governance of reform efforts at the local level.

An Overview of the Governance of Statewide Systemic Initiatives

The governance structures of the 21 SSIs vary considerably. Some of the initiatives are highly centralized and structured; others are only loose collaboratives. Some are lodged in existing state agencies; others have their locus of control outside the state bureaucracy. Teachers and discipline-based professional organizations are taking leadership roles in some SSIs but are hardly visible in others. Although all of the SSIs have involved representatives from appropriate state agencies, the schools, the colleges, and professional groups (in part because it was a condition of funding by NSF), some have been more aggressive than others in their efforts to involve leaders from business, the science and mathematics communities, civic organizations, and the media. Moreover, some SSIs appear to be run by their lead agency, giving only advisory roles to stakeholders from outside a core leadership group, while others are participatory collaboratives with broad involvement in decision-making.

A few brief examples will illustrate some of the variety and complexity of SSI governance structures:

Ohio — Project Discovery is co-sponsored by the Ohio Board of Regents (OBR) and the Ohio Department of Education. The project directors represent those two agencies, but there are also two principal investigators located at Miami University and Ohio State University. The governance structure has three tiers. First, there is a Directors' Council that sets policy for Project Discovery. It is composed of the project directors, principal investigators, statewide coordinators, and staff representing participating universities. Second, there is a Coordinating Council of 30 members representing diverse institutions, which is charged with integrating the components of the SSI and establishing Action Groups to carry out its policies. Third, there are eight Regional Councils, responsible for overseeing day-by-day project activities within the Discovery regions.

South Dakota — The South Dakota SSI is overseen by a 15-member Board of Directors appointed by the governor, which includes representatives from education, business, higher education, state government, and the general public. The Board advises the SD SSI staff, who, in consultation with the Department of Education and Cultural Affairs and the state Board of Regents, sets policies, goals, timelines, and budgets. There is a separate South Dakota SSI National Advisory Board, formed to provide expert advice on best practice to the SD SSI staff.

Vermont — Although the NSF grant was awarded to the Vermont Department of Education (VDE), the Vermont SSI is governed and managed through a new nonprofit agency, the Vermont Institute for Science, Mathematics, and Technology (VISMT). VISMT was created to get broader participation and to avoid bureaucratic problems. However, the VDE also wanted SSI activities to be coordinated with statewide reform initiatives. Therefore, the governor appoints one member to the VISMT Board, the Commissioner of Education nine, and Secretary for Development and Community Affairs five. The VISMT Board is chaired by the deputy commissioner of the VDE and includes representatives from the schools, colleges, professional groups, and business. However, the majority of the Board come from business and higher education. The Board takes an active role in shaping policy and intends to track expenditures, monitor outcomes, and hold the staff accountable for implementing the plans that are approved.

Table 9 presents a more general picture, classifying the statewide systemic initiatives by their lead agency, and suggests some of the variety in the character of SSI governance structures. In 11 states, the state education agency (SEA) is taking a lead role, although in 4 of these cases, the agency is sharing this responsibility with the state higher education authority or an institution of higher education. In three states, an institution of higher education serves as the key lead agency. In the other states, nonprofit organizations located outside the state bureaucracy and, in some cases, outside the formal education system, are taking the lead roles in their states' SSIs.

We recognize that the locus of the lead agency does not necessarily indicate anything about the nature of its decision-making or the breadth and character of participation. Still, this broad range across the 21 SSI states underscores the innovative nature of the SSI program—and how states are often breaking the mold of traditional operating procedures to promote their reform agenda. Of particular interest, because of their innovative governance structures, are the seven states in which the SSI is officially located outside the state education system, and we discuss these in the next section.

Table 9

SSI LEAD AGENCY

State	State Education Agency	SEA/State Higher Education Organization	SEA/IHE	IHE	Preexisting External Agency	New External Agency
CA	✔					
CT						✔
DE			✔			
FL	✔					
GA				✔		
KY					✔	
LA		✔				
MA	✔					
ME						✔
MI	✔					
MT					✔	
NE				✔		
NC					✔	
NM						✔
OH		✔				
PR				✔		
RI	✔					
SD		✔				
TX	✔					
VA	✔					
VT						✔

External Leadership

Although the majority of statewide systemic initiatives are led by the state education agency or the state agency working in partnership with higher education, organizations "external" to the bureaucratic hierarchy are taking leadership roles in some states. Some of these, like the Kentucky Science and Technology Council and the Montana Council of Teachers of Mathematics, are not new, but they are taking on new responsibilities. Others, such as the Council for the Advancement of Mathematics and Science Education in New Mexico and the Connecticut Academy for Education in Science, Mathematics, and Technology, are new broad-based collaboratives created to promote reform. Such organizations are of particular interest because of their unique relationship to the formal decision-making hierarchy, and because of the claims that the participants make about the potential benefits of this approach. New or old, these "external agencies" must establish themselves as potent forces in state-level policy formulation.

The seven states and their SSI lead agencies are:

Connecticut	Connecticut Academy for Education in Science, Mathematics, and Technology (new)
Kentucky	Kentucky Science and Technology Council
Maine	Maine Mathematics and Science Alliance (new)
New Mexico	Council for the Advancement of Mathematics and Science Education (new)
Montana	Montana Council of Teachers of Mathematics
North Carolina	North Carolina Science and Mathematics Alliance (a program of the NC Board of Science and Technology)
Vermont	Vermont Institute of Science, Mathematics, and Technology (new)

In each of these eight cases, the state education agency is involved in the SSI. In half of them, the SEA is serving as the fiscal agent for the SSI. In some, the SEA is an active collaborator; but in all eight cases, an external group acting with some degree of

independence from state government and the state educational establishment is setting the agenda, making policy, and overseeing the implementation of the SSI.

The compositions of these lead groups differ, but what they have in common is that their governing boards and their leadership are not dominated by state agencies, and that they operate independently of the normal state bureaucracy. A third common feature is that business leaders are generally playing a much larger role in guiding the SSIs than they do in those states where the SSIs are led by the education agencies. Below, we describe two of these external governance structures—a wholly new entity in Connecticut and a preexisting organization in Kentucky.

Connecticut: Business-Led Collaboration in the Service of Reform

The Connecticut Academy for Education in Science, Mathematics, and Technology is regarded by its advocates as the centerpiece of the state's systemic initiative and, potentially, the focal point for mathematics and science reform in the state. The leadership of the Academy is attempting to bring leaders from the schools, higher education, mathematics and science communities, state government, business, science-rich institutions, and civic organizations together to promote a common reform agenda. Led by a former corporate executive, the Academy staff is small but well connected to all the major stakeholders through the Academy's Board. Both the Board and the staff see the Academy as the key to the sustained and focused reform effort that they believe will be necessary to have a powerful impact on teaching and learning in mathematics and science.

The Academy does not operate programs directly, but instead works through other institutions such as school districts, colleges, museums, the Department of Education, and the media. In this way, it does not compete with other institutions but seeks to strengthen them. The Academy sets priorities for the SSI, uses a competitive grant process to mobilize the resources needed for particular tasks and to get institutions working together, and monitors the use of funds and the success of activities. The Academy articulates the vision and serves as the catalyst to build public and institutional support for it.

The uniqueness of the Academy in Connecticut's history lies in its autonomy from the bureaucracy and its capacity to convene key players from different sectors who have seldom talked in the past. The most important accomplishment in the first year was getting policy-makers to recognize the Academy as the lead agency in the area of mathematics, science, and technology. The Academy has the support of the lieutenant

governor, key legislators, the Department of Economic Development, the commissioner of higher education, and the commissioner of education. However, the degree to which the state Board of Education and the commissioner of education are committed to supporting the Academy's leadership role and to coordinating their efforts with it is not yet clear. There was also some resistance in the state Department of Education. Some policy-makers did not want an outside group conflicting with the role of the state Board of Education by setting policy or lobbying the legislature. Because the Academy has no legal authority, however, the state department officials eventually agreed to its creation and its role as the lead agency.

Kentucky: Building on a Tradition of Industry-Government Cooperation

Although the cooperative agreement for the SSI in Kentucky (known as PRISM) is between NSF and the Kentucky Department of Education (KDE), the SSI is being led and managed by the Kentucky Science and Technology Council (KSTC), a nonprofit organization, working in cooperation with the commissioner of education, who serves as one of the PIs. The Council was initiated by Governor Marva Collins in 1987 as an advisory council made up of representatives of business and academia interested in attracting high-technology industry to the state, improving the skills of the workforce, and promoting technology transfer in Kentucky. It soon become an autonomous organization.

KSTC works with state agencies and has raised private funds from corporations and foundations to support its work. It serves as the state coordinator for EPSCoR (Experimental Program to Stimulate Competitive Research), and is working with the state on public-private partnerships and technology transfer. KSTC has been active in education for some time, running inservice programs in science and technology and developing curriculum modules in science. PRISM is its largest undertaking, representing 40% of KSTC's budget. Prior to SSI, the NSF-funded elementary science project at UK was its main activity.

PRISM has its own board with broad representation, including the governor, several key legislators, representatives from the Education and Humanities and Economic Development Cabinets, several SEA officials (including the commissioner), representatives of higher education, several business leaders, and several local officials. This board serves as an advisory group to KSTC but does not appear to set policy or get heavily involved in

management of the program. The board does provide strong links to stakeholder groups, and its role is still evolving.

The president of KSTC, the KSTC SSI director, and the commissioner of education work closely together to coordinate the SSI with the larger reform initiative in the state. KSTC staff coordinate the work of the nine SSI component directors, of whom four are affiliated with universities, three are in KDE, and two are at KSTC itself. KSTC seems to have recruited the key players from the mathematics and science communities. Everyone with whom we spoke expressed comfort with the collegial style of decision-making used by KSTC staff. The component directors meet monthly to work out operational issues and develop plans for implementation.

Internal Leadership

Leadership from within existing state agencies is a much more familiar situation for state and federal officials who are dealing with single awards for statewide education improvement efforts, whether in mathematics, science, or other subjects, or for general school improvement efforts (such as those supported by the U.S. Department of Education's Chapter 2 funds under the Elementary and Secondary Education Act). As noted earlier in Table 9, about half of the 21 SSIs have this type of leadership. Michigan, Texas, Rhode Island, and California are among those states in which the SSI awards have been made to a state agency and where the key SSI leadership is located within the state bureaucracy.

Internal leadership has a variety of apparent advantages for the SSIs. For example, in these cases, one would expect the project to benefit from close working relationships with existing state and federal programs. In Michigan, the project director, located in the state Department of Education, was previously a coordinator of the Eisenhower Mathematics and Science Education Program, and thus is well positioned to understand the history of earlier state and local reform efforts in mathematics and science education, as well as to take advantage of "leveraging" the Eisenhower funds for the SSI. In fact, Michigan reported using a sizable amount of Eisenhower funds to support its systemic initiative.

On the other hand, cooperation within and across governmental agencies is not always easy to obtain. There are SSIs in which "turf battles" have prevented internal

leadership groups from obtaining the maximum benefit of their knowledge and access to the levers of government.

We describe here in somewhat more detail the governance structure for one SSI in which the award has been made to a state agency.

California. California has adopted an approach that keeps the systemic initiative closer to the key state personnel concerned with mathematics and science than have the SSIs governed by external agencies. Here, the principal investigators are located in the state Department of Education and the governor's cabinet, and the oversight responsibility remains largely within the state education agency. The former science supervisor for many years and the state's mathematics supervisor are in leadership positions, bringing with them a long institutional memory as well as many accomplishments in shaping the state's ambitious role in mathematics and science education. California's mathematics and science frameworks, the pressure that it placed on publishers to reform instructional materials, and its plans for statewide performance assessments are testimony to the work directed and endorsed by the state agencies over many years.

At the same time, the California initiative does have a diverse board of directors external to the state department, and it has teamed up with an institution of higher education, the regional education laboratory, and a number of reform efforts based at institutions of higher education to ensure the successful implementation of its reform strategy. The effort thus is closely coordinated with other state reform efforts. Although California has paid attention to building networks with other key players in the state, efforts to reach out to new private-sector collaborators are not nearly on the level of some of the externally led SSIs, such as Connecticut's.

Partly as a result of the decision to work within the current system, not to create a whole new organization nor to focus as much on coalition building at the state level, California has been free to focus on direct service provision. Thus, one of the key accomplishments of the California systemic initiative in its first year has been the development of two statewide teacher professional development networks reaching over 1,000 teachers with relatively intensive professional development services (more than 30 hours per teacher).

External or Internal Agencies: Finding the Best Means of Promoting Reform

Almost every SSI has made significant efforts to collaborate across several different agencies, and collaboration is clearly a key to effective systemic reform. It is easy to exaggerate the differences between governance structures that lie primarily inside or outside state government, and we have perhaps done so, in the interest of clarifying some of the strengths and weaknesses of each governance form. Nonetheless, there are some real differences.

The rationale given by those who have placed the locus of decision-making for the reform of science, mathematics, and technology education outside of state government vary, but among the reasons stated are:

- Avoidance of red tape and the capacity to act faster and to spend funds with fewer restrictions.
- The ability to hire or attract better-qualified staff.
- The capacity to build greater credibility with the mathematics and science communities, as well as within the business community.
- The ability to serve as more effective advocates for reform, uninhibited by other state agendas or changes in state priorities.
- The ability to sustain a long-term effort, surviving changes in state leadership.
- The ability to make the initiative bipartisan.
- Increased capacity to raise private funds.

Research provides some support for the argument that nongovernmental bodies may have certain advantages over government as the sources and monitors standards and the quality of practice (Fuhrman, 1993). First, agencies external to the government may be able to gain greater acceptance with teachers because they are less threatening than government. Second, external agencies may be able to maintain membership and authority across electoral cycles more easily than government agencies, enabling them to maintain their focus even as political personalities and priorities change. Third, nongovernmental bodies may be able to attract volunteers and in-kind resources and be less costly to operate; they also may be better able to tap private funds so that they, and their missions, become less vulnerable to state budget cuts.

Yet, external agencies may have some serious weaknesses as well. Functioning outside the system, they could increase the complexity of policy-making by adding a new layer of consultation and review. In some cases, the creation of external agencies may take valuable time and resources away from substantive activities; at worst they could make a fragmented system less rather than more coordinated.

The limited data we have from the evaluation's first year do not allow us to draw conclusions about the benefits and costs of governing a statewide systemic initiative inside or outside of the state bureaucracy. There are potential advantages and disadvantages to both. Thus for example, preliminary analysis of state initiative budgets suggests that externally governed initiatives are indeed more successful than their state-run counterparts in raising funds from external sources. Yet, not surprisingly, initiatives governed within the state bureaucracy appear more successful in leveraging Eisenhower and other state funds.

The contrasting examples of Connecticut's and California's statewide systemic initiatives illustrate some of the tradeoffs involved in varying governance structures. Although these states are dramatically different in many ways (size, population, and political culture), both have enjoyed vigorous state leadership in education, reform-minded chief state school officers, respected capacity in the state education agencies in mathematics and science, cutting-edge state assessment programs, and state leadership in promoting new ways of teaching and learning. However, they have taken quite different approaches to governing and implementing their SSIs, as we have noted above.

The differences between their two strategies may be attributed to the states' different political cultures or to other factors. Regardless of their origins, the important question is whether the governance structures in the two states and their relative focus on coalition building will influence the long-run success of their systemic initiatives or "buy" them different kinds of gains. It is, as yet, too soon to answer these questions.

Summary and Questions

Although it is too soon to reach conclusions about the performance of the various governance mechanisms, it is remarkable to note how many of the SSIs have reached outside existing governmental agencies for leadership and assistance. The number of cases in which this has occurred suggests that many states have concluded that changing the status quo will require creative means and new sources of support. It may not be

necessary that external agencies play any *particular* role, and it may well be that what is needed varies from state to state. But it is quite possible that one contribution of the SSI program will be to demonstrate the contributions of external agencies to statewide systemic education reform, and future findings may offer important lessons for future federal initiatives.

The above discussion raises a number of questions to be addressed by the evaluation project, such as:

(1) Is there any relationship between the governance structure and the capacity to win support for reforms from school districts, the legislature, or the public?

(2) Is there any relationship between the governance structure and the capacity to raise public or private funding for mathematics and science reform?

(3) Is there any relationship between the governance structure and the capacity of the initiative to be sustained past the 5 years of NSF's funding?

(4) Do externally governed SSIs come into conflict with SEAs as a result of conflicts over priorities, state funding, standards, etc.? If so, how are such conflicts resolved?

(5) Does the creation of new governance structures reduce the possibility of increasing coordination among state agencies, thus limiting the capacity to create more coherent state policy?

5 LOOKING AHEAD: CHALLENGES FOR FURTHER EVALUATION

This report is being written after the states have had, at most, 2 years of support from the SSI program. Moreover, a number of the SSIs have gone through major reorganizations since their inception. Overall, many of the SSIs are still in either a start-up stage or a stage of rapid growth and evolution. Similarly, the national evaluation of the SSI program is at an early stage. Up to this point, all of our fieldwork has been conducted in only nine states, and nearly all of it has focused on people and events at the level of state agencies and institutions.

The result, as we have suggested in earlier chapters, is an interim report that provides preliminary information. This report is largely descriptive; we have purposefully reached few conclusions about the SSI program or the individual SSI initiatives. Rather, we have concluded each chapter with specific questions for future research. Addressing these questions presents a number of particularly significant challenges that face the research team in carrying out the next phase of research. In this chapter, we focus on three special challenges for the evaluation:

(1) SSI is embedded in a complex array of other reform efforts. The national evaluation needs to develop methods for "standing back" and examining SSI in this larger context.

(2) The first year of research has focused especially on people and institutions at the state level. The evaluation must examine other levels of the education system and integrate findings across levels, from the classroom to the state capital.

(3) The theory of systemic reform focuses on key policy issues, such as assessment of student learning, that are extremely complex in their own right, let alone when considered as parts of much larger initiatives. The evaluation needs ways of focusing greater attention on these complex issues while not losing sight of the SSI program as a whole.

In this chapter, we focus on each of these challenges in turn and propose methods for meeting them.

Understanding SSI in the Larger Context of School Reform

A wide array of state and federal reform efforts are under way that affect schools and thus the SSI program itself. In the second and third chapters of the report, we

discussed the issues involved in assessing the statewide systemic initiatives in the context of ongoing state mathematics and science reforms. Yet, there are a number of other reforms, many of them national in scope, whose influence on SSIs we have not tracked closely. We discuss these below.

School Finance Reform

Perhaps the most dramatic and far-reaching of the school reform efforts under way are those resulting from court decisions in school finance cases. Typically, the stimulus for reform is a claim or finding that the current finance system is inequitable. Thirty-seven states are involved with school finance reform. In one SSI state, Kentucky, the state supreme court's decision to invalidate the then-prevailing method for financing schools (predominantly through local property taxes) was the single "cause" that led to an enormous number of changes, ranging from new district and school governance policies to brand-new, high-stakes state assessments of student achievement. Many of the 21 SSI states are affected, although few states have seen such rapid and sweeping impacts as Kentucky. Texas, Montana, and Michigan are just three of the other SSI states currently embroiled in revisions to their finance systems.

School finance reforms can lead to protracted debates and political conflicts that may paralyze other efforts to reform education, as they did for some time in New Jersey and Texas. However, they also can be the stimulus for broader, more systemic reforms as in the case of Kentucky, and new school formulas can provide the resources needed to address some of the fundamental barriers to equity in mathematics and science education, such as the lack of qualified teachers, professional development, textbooks, lab equipment, computers, and other essentials in poor school districts. In states where such basic inequities persist, it may not be possible to close the gap in mathematics and science attainments.

Other Changes in State Education Systems

There are other potential big policy changes in the states that could affect the course and the impact of the SSIs. For example, the *Sheff v. O'Neill* desegregation case in Connecticut has focused the state's leadership on the issue of district organization, and this case could undermine efforts to place mathematics and science reforms high on the state agenda. On the other hand, it could create an opportunity for bold initiatives to address the gap in access and attainment in science and mathematics for minority students.

The vote on vouchers in California and the property tax referendum in Colorado are examples of other larger educational policy decisions that might affect the course and progress of an SSI.

State budget problems also are likely to affect the course of the SSIs. Reductions in state agency budgets reduce SEA capacity for technical assistance and slow the development of new assessment systems and curriculum frameworks. In spite of the current slow economic improvement, many states still face budget deficits and many are reducing their workforces.

Federal and National Reform Efforts

The importance of the pending reauthorization of the Chapter 1 program has already been noted. Chapter 1 funds turn a massive wheel whose momentum can either reinforce reform, impede it, or power an education system that is effectively parallel to or isolated from the system that SSI aims to change.

The new administration's other education reform initiatives, Goals 2000 and the School-to-Work Transition statutes, also could affect the SSIs. Goals 2000 calls on all states to develop a plan for systemic reform. This could strengthen SSIs by providing new impetus for the reforms in the states, strengthening public support, and generating additional state and federal resources; or, in the worst case, it could create competing coalitions and struggles over leadership and control of the reform agenda in state capitals and serve as a temporary distraction. The administration's School-to-Work Transition legislation is designed to encourage a systemic approach to education for youth leaving school and preparing to enter the workforce. A number of the strategies for reform involve program options that bring academic subjects (particularly mathematics and science) and vocational studies into new relationships. These strategies include the Tech.-Prep. model, youth apprenticeships, and the Career Academy model. Each of these approaches is being widely implemented and involves an applied academic curriculum that could well be considered consistent with the "hands-on," constructivist theories underlying the NCTM *Standards* as well as the various efforts to develop standards for science education. Yet, up to this point, it appears that only a few of the SSIs have made strong efforts to integrate the vocational education system into their systemic reform efforts.

Another federal program of great significance to SSI is the Eisenhower Mathematics and Science Education Program, administered by the U.S. Department of Education. The

national portion of this program has recently awarded grants to 16 states to develop state curriculum frameworks in mathematics, science, or both. Of these 16 awards, 11 are to states that also have received SSI funds. The state and local portions of the Eisenhower program are even more critical to the SSIs. The SSI states claim that last year more than $20 million in Eisenhower funds was used *directly* in support of SSI. More than $200 million was obligated for the state and local programs last year, and *all* of it was to support reform in mathematics and science education. Any changes in the Eisenhower program *could* have an effect on the SSI program, and the pending reauthorization of the program needs to be kept in mind as the national study conducts additional fieldwork this year.

NSF itself is undertaking a new Urban Systemic Initiative. Many of the cities eligible for these grants are located in states with SSIs. The historic competition between state officials and the leadership of large cities such as New York, Los Angeles, Miami, New Orleans, Boston, and Detroit may require special efforts by NSF to ensure that state and local SSIs work together and not at cross-purposes.

Finally, many of the SSI states are active in other national reform efforts. For example, both the New Standards Project and Re: Learning are impacting the evolution of statewide reform in a number of SSI states.

One Reform Effort, Or Many?

All the states are involved with the Chapter 1 program, and all will be affected by pending federal legislation affecting Chapter 1, Eisenhower, and other programs that interact in one way or another with the SSI. Many SSI states also have under way a variety of reform efforts of their own. Thus, in every SSI state, two important questions are how many reform efforts are being implemented and whether they are coherently aligned with one another.

NSF and the U.S. Department of Education are making efforts to align their strategies for reform, and this attempt is important. A recent policy brief jointly developed by the agencies states that:

> *The two agencies should produce clear signals that State activities financed through our respective programs should contribute to a single, integrated reform effort, not to one effort*, funded by NSF, that focuses on mathematics and science education and a second one, funded by ED, that looks at the broader curriculum. (U.S. Department of Education; 1993, p. 3)

State policy-makers must heed this advice, as well. Policy alignment and coherence will be needed for systemic reform to succeed.

Implications for the National Evaluation

This complex array of reform efforts has several implications for the national evaluation of the SSI program. First, we need to expand the list of people whom we interview and documents we review, especially in the case study states. For example, we need to interview individuals involved with the Chapter 1 program—at the state, district, and school levels. Of particular importance, we need to pay attention to possible tensions at the local level between mathematics reform and the traditional basic-skills approach on many Chapter 1-funded efforts. (Typically, Chapter 1 has little direct relationship to science education.)

Second, as we select two additional case study states from among the five Cohort Three states recently awarded SSI funding, the selection should be guided, in part, by the need to understand SSI in as broad a context as possible. In particular, few states in our current case study sample focus much effort on reform of the vocational education system, despite its large size and significance in the secondary education system. If we can add a state that is integrating SSI and the reform of vocational education, we will enlarge our understanding of how these reform efforts interact.

Finally, because of the complexity of the SSIs and their contexts, our examination of the non-case-study states is handicapped if we cannot visit them and conduct interviews of a wide range of respondents. Consequently, NSF has provided the evaluation team with sufficient funds to make brief visits each year in a dozen of the non-case-study states. These will provide us with substantially more information, not only about the SSIs but about other reform efforts under way in these states.

Examining the Various Levels of the Education System

Systemic reform, by definition, involves changes throughout the educational system. The ambitious vision, coherence, capacity building, and mobilization of opinion in support of reform that have to take place on the statewide level must be matched by similar efforts at the local level. Ultimately, systemic reform's goal is to improve what takes place in classrooms between teachers and students and what students know and are able to do. However, up to this point in the national study, most of our attention has been devoted to

understanding SSI from the point of view of state-level actors. During the second and subsequent years of the study, we will begin to look through the educational system to broaden our focus to include districts, schools, classrooms, and institutions of higher education.

Fieldwork this coming year (1993-94) in the nine case study states from Cohorts One and Two will include a significant amount of time at the local level. In all nine states, this will include visits to school districts, typically three per state, and to several schools in each of the districts (typically three per district). We plan to include both schools and teachers that have been directly involved in SSI-sponsored activities and schools and teachers that have no direct involvement. Schools in which SSI is a major factor—such as pilot or demonstration schools, or schools containing SSI-trained "lead teachers"—can be compared with others in which SSI is a less prominent factor. By studying science and mathematics education in comparison schools, in which SSI has not been such a significant factor, we hope to be better able to determine the relative influence of SSI as compared with other programs and initiatives. Of course, we realize that for some elements of systemic reform, such as state-mandated assessment programs, it may not be possible to find "comparison" schools that are not affected at all.

In addition, in those states in which SSI has a substantial focus on undergraduate education (including teacher preparation), local visits will include at least one institution of higher education. Visits to districts, schools, and institutions of higher education will be continued over a period of several years, so that the progress of SSI over time can be examined.

At the same time, we will continue to collect information from state-level actors through written documents (such as annual reports to NSF) as well as interviews. This strategy of focusing on both the state and local levels will contribute to an understanding of the interaction between levels.

Understanding Key Issues in Depth

The first two challenges to the evaluation that we have discussed above both require that we be able to broaden our view of what is happening in schools to include, first, the influences of a wide variety of reform efforts and, second, the interaction of decisions and actions taken at many levels of the education system. Meeting these challenges requires that the evaluation have available methods that act something like a wide-angle lens,

taking in a very large field of view. In contrast, the third challenge requires us to narrow our field of view and look in much greater detail at a few, key issues.

These issues are the ones that are linchpins of the theory of systemic reform, including: the creation and implementation of state curriculum frameworks in science and mathematics education; developing and using new student assessment systems; and how best to build up the capacity of the education system (e.g., by providing professional development to teachers with sufficient depth and breadth to make a difference). Any one of these issues is highly complex. We found during the first year of the evaluation that our methods for tracking them were insufficient. For example, we have been interested in the development and use of curriculum frameworks in the SSI states. We have focused on this issue in interviews and in our review of documents. Yet, we found that what states mean by "frameworks" varies so considerably that any reasonable judgments about them must rest on a much more thorough analysis than we carried out. We must examine the quality of the frameworks, their relationships to national standards, their specificity, and the extent of their use.

As we move into the second year of the evaluation, we are planning more in-depth analyses of certain features of the SSI reform efforts, such as curriculum frameworks. We plan to create small teams within the core study group, charged with the task of analyzing certain issues across the states. We will carry out these efforts in coordination with other ongoing efforts of similar scope. For example, in looking at curriculum frameworks, we would coordinate our work with that of other NSF-funded studies (e.g., the work of the Council of Chief State School Officers) and with Department of Education work (e.g., the evaluation of the Eisenhower Framework projects). We expect that these efforts will result in content-specific policy briefs that will be published separately from our annual reports.

We hope that these three efforts—focusing on the broader reform contexts in which statewide systemic initiatives are evolving; turning our attention to districts, schools, and classrooms; and putting effort directly into the assessment of states' efforts in key policy areas—will strengthen the evaluation greatly. Tracking the progress of the (now) 26 statewide systemic initiatives and examining the strengths and weaknesses of the SSI program as a federal change strategy presents a daunting challenge for researchers; yet our task pales in comparison with the job of actually reforming the system of mathematics and science education to which both the states and the federal government are committed.

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